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GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

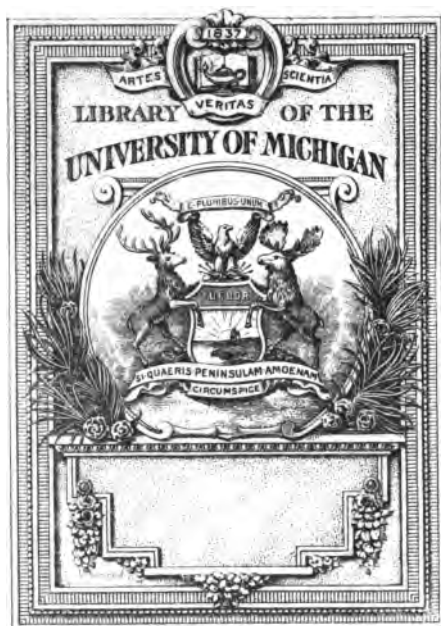
OF THE

STATE GEOLOGIST,

FOR THE YEAR

1883.

CAMDEN, N. J.:
PRINTED BY F. F. PATTERSON.
1883.

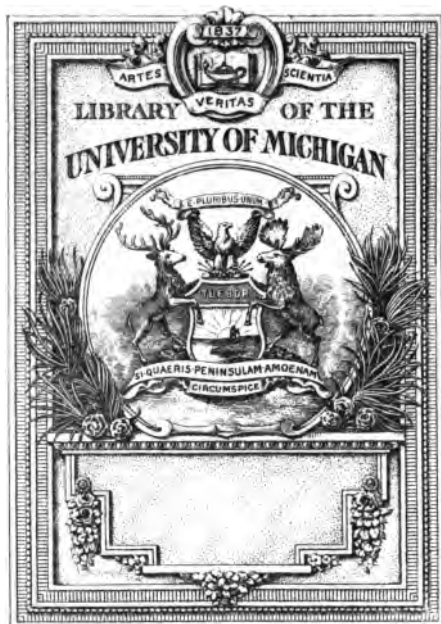


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NEW BRUNSWICK, December 13th, 1883.

To His Excellency George C. Ludlow, Governor of the State of New Jersey, and ex officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report as State Geologist for the year 1883.

With high respect,

Your obedient servant,

GEO. H. COOK,
State Geologist.

REPORT.

The Geological Survey of New Jersey has been continued the past year. The largest part of the work and of the expense has been given to pushing forward the Topographic Survey, and good progress has been made. The Geodetic Survey of the State has also been continued, and the largest part of that work is now done. There has also been considerable time given to work in which the results of former work in the survey have been practically applied. Those relating to water-supply, to artesian wells and to mining will be given at greater length farther on in this report. And the uses and benefits of the survey, which is carried on at the expense of the State, and to develop its natural resources, are making themselves more widely known every year.

The different departments into which the work divides itself will now be taken up separately.

I.

GEODETIC SURVEY.

This survey is made as a part of the United States Coast and Geodetic Survey, and at the expense of the United States Government. It is done under the direction of our Geological Survey, by authority of the act of Congress which directs the Coast and Geodetic Survey to aid States which are carrying on geological and topographical surveys. The accompanying small State map has marked on it the points which have been accurately determined in latitude and longitude in this survey. Those marked with a small triangle are *primary stations* which have been occupied, and from which angles have been measured to numerous other points. The numbers on points refer to their names which are given in the following list. Those marked by a dot are *tertiary stations*. No numbers are attached to them. They have been observed upon from the primary stations, but have not been occupied and used as stations for measuring angles. A list of those which have been observed upon from the High Torne and High Mountain, during the past summer, are given below. •

The points which have been selected for primary stations in the southern part of the State, but have not yet been occupied for measuring angles, are each designated by a small circle and a number, and they are set down in the list with the other primary stations.

An inspection of the map will show that nearly the whole of the State is dotted over with the marks of these points of triangulation. The latitude and longitude of each of these stations are determined with such accuracy that they are not in error for more than a very few inches. This work needs to precede the topographical survey, as the latter has to be mapped so that all its parts shall be correctly adjusted about these points which are the fixed and accurate marks of reference. On some of our maps of recent date, where points of latitude and longitude had not been accurately settled, the maps were in

error in the proper location and relation of their parts as much as a mile and in some cases more.

LIST OF PRIMARY STATIONS DETERMINED.

No. on Map.	Name.	No. on Map.	Name.
1.	High Point.	21.	Disboro.
2.	Culver's Gap.	22.	Willow Grove, Pa.
3.	Hamburgh.	23.	Stoney Hill.
4.	Bear Fort.	24.	Mount Holly.
5.	Torne, N. Y.	25.	Gowdy's House.
6.	Buttermilk Hill, N. Y.	26.	Yard, Pa.
7.	Bald Hill.	27.	Pine Hill.
8.	High Mountain.	28.	Apple-Pie Hill.
9.	Mount Olive.	29.	Ridgeway.
10.	Montana.	30.	Barnegat Light House.
11.	Weasel.	31.	Bethel, Pa.
12.	Springfield.	32.	Lippincott.
13.	Big Rock, Pa.	33.	Meeting-house Hill, Pa.
14.	Haycock, Pa.	34.	Buck, Del.
15.	Pickels.	35.	Burdon.
16.	Goat Hill.	36.	Deakyne, Del.
17.	Mount Rose.	37.	Pine Mount.
18.	Mount Horeb.	38.	Deepwater, Del.
19.	Beacon Hill.	39.	Joscelyn.
20.	Newtown, Pa.		

LIST OF STATIONS SELECTED, BUT NOT YET DETERMINED.

No. on Map.	Name.	No. on Map.	Name.
40.	Small's Ridge.	44.	Weymouth.
41.	Hammonton.	45.	Egg Harbor.
42.	Spring Hill.	46.	Newfield.
43.	Williamstown.	47.	Estellville.

TERTIARY STATIONS.

The following is a list of the tertiary stations observed upon during the past summer :

FROM HIGH MOUNTAIN.

Brooklyn Bridge.	Powder Mills.
Fairfield.	Caldwell Church.
Boonton Church.	Hackensack.
Parsippany.	Passionist Fathers Monastery.

ANNUAL REPORT OF

Englewood.
 Coytesville.
 Morristown.
 Bergen Fields (Schraalenberg
 S. Church).
 Another church spire in Hack-
 ensack (not observed upon
 from any other Station).
 Bald Mountain.
 Caldwell Flag.
 Sheep Hill.
 Watnong.
 Ramseys.
 Wyckoff.
 Allendale.

Suffern.
 Palisades.
 Saddle River (not observed
 upon from any other Sta-
 tion).
 Wortendyke (not observed
 upon from any other Sta-
 tion).
 Paramus.
 Schraalenberg (N. Church).
 Greenwood Lake.
 A church spire (not observed
 upon from any other Sta-
 tion).

FROM HIGH TORNE.

Bald Mountain.
 Greenwood Lake.
 Schraalenberg.
 Englewood.
 Wyckoff.
 Allendale.
 P. F. Monastery.
 Coytesville.
 Brooklyn Bridge.

Suffern.
 Bergen Fields.
 Paramus.
 Beach Mountain.
 Palisades.
 Ramseys.
 Hackensack.
 Southfield.

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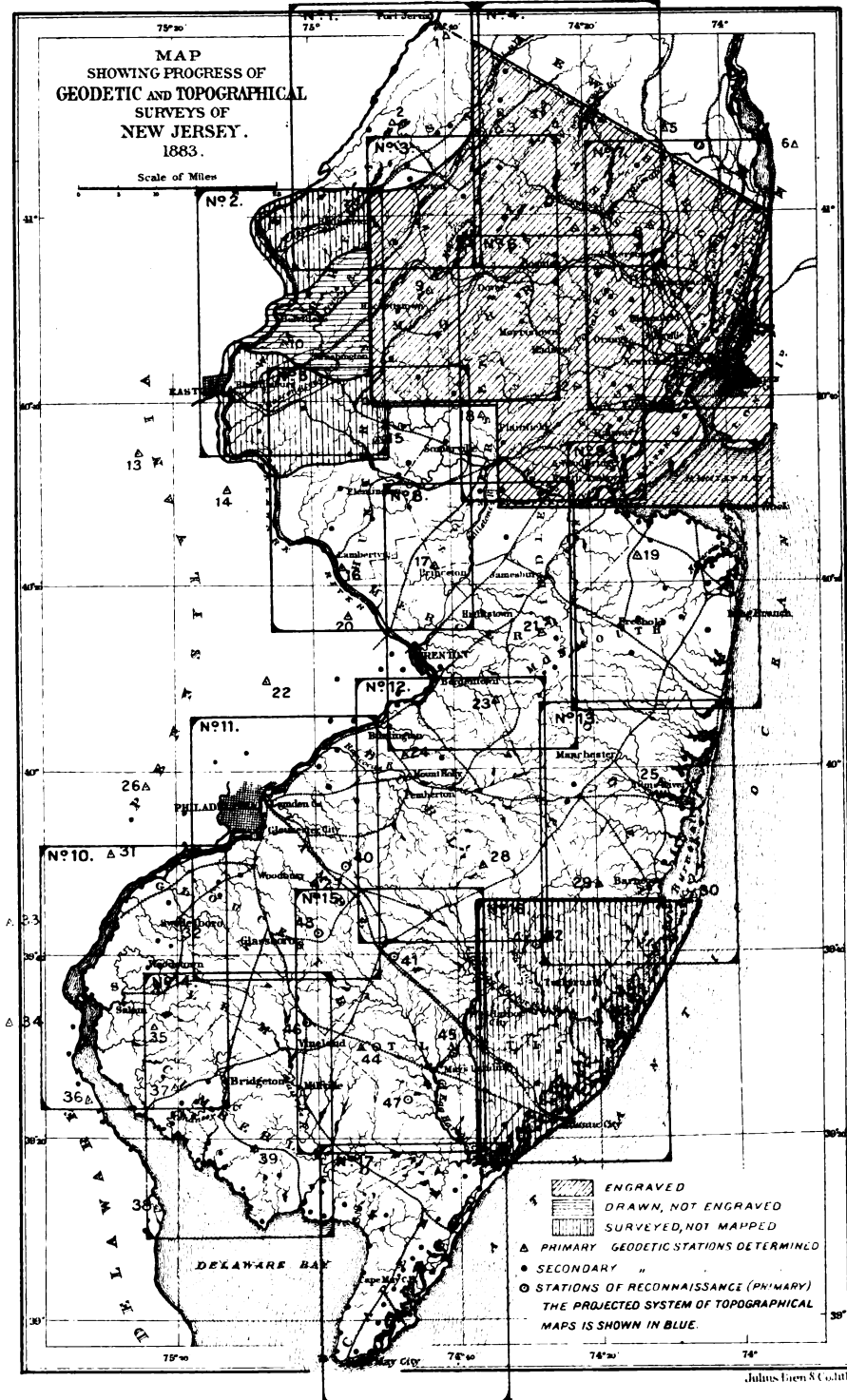
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GEOLOGICAL SURVEY OF NEW JERSEY.

MAP
SHOWING PROGRESS OF
GEODETIC AND TOPOGRAPHICAL
SURVEYS OF
NEW JERSEY.
1883.

Scale of Miles



II.

TOPOGRAPHICAL SURVEY.

The State Topographical Survey has been vigorously pushed forward during the year by Mr. Vermeule and his assistants. At the close of the last year, it was reported that 1,740 square miles had been surveyed, of which 480 miles were done in the season of 1882. During the present year the surveys have extended over 1,116 square miles, and the total area surveyed is 2,856 square miles. The whole area of the State we have estimated at 7,576 square miles, so that very nearly two-fifths of the area of the State is now surveyed. This, however, gives an incorrect idea of the proportionate amount of work done. The surveys over the roughest and most difficult ground in the State are done. And it is safe to say that more than one-half of the labor of the Topographical Survey has been done.

Of the ground surveyed, 1,260 square miles had been mapped, and 847 miles engraved and printed in one map, at the end of 1882. During the past year, 633 square miles have been mapped, making a total area now mapped of 1,893 square miles, and 844 square miles have been engraved and ready for printing. The whole area now engraved is 1,691 square miles.

In preparing the maps for publication, it has been concluded to have them all on a scale of one inch to a mile, which is 1 to 63360, and to have them all of the same size, and as large as they can be conveniently printed on a single sheet of paper. After a number of trials to ascertain what would best fit the irregular shape of the State, and the geological belts which cross it obliquely, having regard also to the location of important centers of population and business, the plan shown on the accompanying small map of the State was adopted.

The entire State requires 17 sheets to cover it. Each sheet is 24 x 34 inches in size. At first view it will be thought that they overlap each other and require an extra amount of engraving. The overlapping

is not more than enough to give room for titles to the maps, and the engraving is not increased, as the printing is not done from the engraved stones directly, but from transfers which can be joined together in any way that may be required.

The numbering of the maps is generally from the north towards the south, and they are arranged so that those covering the same geological formation can be easily grouped together, thus:

Nos. 1, 2, 3 and 4 cover all the Archaean and Paleozoic rocks.

Nos. 2, 3 and 4 cover all the Archaean rocks and all the iron ore district of the State.

Nos. 5, 6, 7 and 8 cover the red sandstone formations.

Nos. 8 and 9, with 10, 11 and 12, cover the clay and marl districts of the State.

Nos. 9, 13, 16 and 17 cover the entire Atlantic shore.

The sheets can be taken separately or the whole together. The maps are all drawn on the same system of projection so that any two adjoining ones can be cut, fitted accurately to each other, and made into a single map, or they can be folded across and put in an atlas of 17x24 inches. These, with a map of the whole State, on a scale of five miles to an inch, and which will go on the same sized sheet, will make a complete atlas of New Jersey.

The contour lines are drawn on these maps so as to show every rise of 20 feet elevation in the hilly portions of the State, and every 10 feet in the more level portions. They furnish the data from which important public undertakings for drainage, for water-supply, for the location of roads, railroads, selection of routes of travel, sites for buildings, &c., may be intelligently studied out. Already they have found important uses in forwarding public improvements, and they will become indispensable for every citizen interested in public affairs.

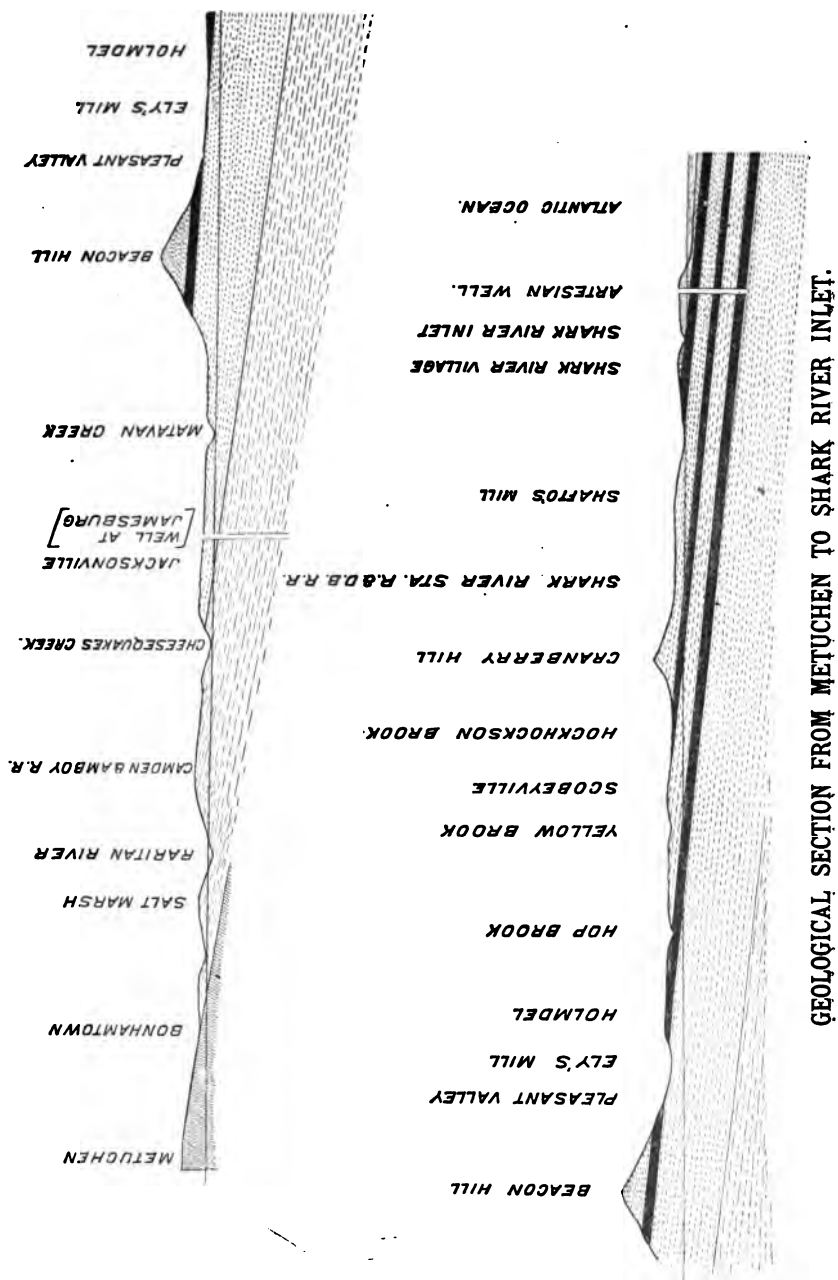
NOTE.—As the first maps of the series will be distributed this winter, while those following may be issued at intervals of several months, persons receiving the first may find it convenient to preserve them in such a way that others can be bound in with them in the same atlas.

III.

TERTIARY AND CRETACEOUS FORMATIONS OF SOUTHERN NEW JERSEY.

In preceding reports, the geological structure of these formations has been given. They are all in pretty uniform and regular strata, which, instead of lying level, are inclined towards the southeast, with a dip of from 50 to 20 feet to the mile. As the dip of the strata farthest southeast was the most gentle, and we had no other measurements to guide, we were led to consider that there was a diminution of the dip in the advance in that direction. And while the beds of green sand marl are easily distinguished from each other by their characteristic fossils, and some of the fossils of the upper or third marl bed were of tertiary forms, while all the others were cretaceous forms, still it was not easy to draw a well-defined line between these two great formations. There was no exposure where they were plainly unconformable but the passage from one formation to the other appeared gradual and without break. In the last report on the geological survey, attention was called to the important fact that some of the strata were very sandy, and would most probably yield good water for domestic use if they were pierced by bored wells; and, assuming that the red sand bed overlying the lower marl bed should yield water, the depth was calculated at which water could most likely be obtained at various places along the sea-shore and on the beaches. The calculation was made by allowing the dip or descent of the strata to be 20 feet to the mile, and these depths were put in the report and marked upon the map accompanying it.

The observations of the past season indicate that the cretaceous and tertiary beds are not conformable, but that the tertiary beds, including the upper layer of the Upper Marl bed, are much gentler in their inclination than the cretaceous beds below them. Also, that what has



GEOLOGICAL SECTION FROM METUCHEN TO SHARK RIVER INLET.

heretofore been designated as the ash marl, or middle layer of the Upper Marl bed, is really much thicker where it is bored through at some miles from its outcrop, than it is at the latter line; and that it constitutes the division between the two great formations; though, from the absence of fossils, it is not possible to say at present which one of the formations it belongs to.

The boring of two artesian wells, the first at Ocean Grove and the second at Asbury Park, have furnished important and satisfactory data for determining the dip of the strata with greater precision than it had been possible to get before this, as will be shown farther on in the description.

The marl beds, with their peculiar grains of green sand, are easily distinguished from the other strata passed through, but the colors of the various strata are entirely different from what they are at their outcrops on the surface; what are salmon-colored or yellow, by oxidation, near the surface, are all black, or nearly so, in the same strata as brought up in the well-borings. But the singular and peculiarly marked *Terebratula Harlani*, which is only found in the Middle Marl bed, cannot be mistaken even when broken up by the boring tools, and in the same way the *Belemnitella mucronata*, or "thunderbolt," which is only found in the Lower Marl bed, characterizes equally well that part of the cretaceous formation. Besides, the well-marked grayish carbonate of lime found in fine powder, or earth, in the Lower Marl bed, marks it as perfectly at the depth of 380 feet below the sea-level as it does at other places 50 or 60 miles away and 150 feet, or more, above that level. And the sand marl which lies at the bottom of the Lower Marl, is of the same character.

NOTE.—The geological section opposite, from Metuchen to Shark River inlet, drawn on a scale of four miles to an inch horizontal, and 1,000 feet to an inch vertical, shows the three marl beds by solid black lines, and the beds of sand which separate them from one another, by dotted sections. The artesian well at Ocean Grove is represented at its proper place referred to the line of strike.

The Jamesburg well, described in the report of 1881, also is shown in its proper geological position. It begins in the strata almost immediately under those in which the Ocean Grove well terminates, and continues down through most of the cretaceous strata, and must have ended very near the underlying rock.

that it is at the surface where the bed outcrops. With these particulars given for the identification of the several strata, the description of the successful boring of the Ocean Grove well may now follow.

ARTESIAN WELL AT OCEAN GROVE, MONMOUTH COUNTY.

This well is located at Ocean Grove, a well-known sea-side resort in Monmouth county. It is a flowing well, yielding a daily supply of 60,000 or 70,000 gallons of sparkling, pure and wholesome water. It is the first deep well which has been bored into the water-bearing cretaceous strata of New Jersey, and its success gives assurance that all our sea-side resorts can obtain a like supply of water of unexceptional quality by opening wells into these strata.

This well was bored for the Ocean Grove Association by Mr. H. C. Safford, of Brooklyn, N. Y. The well, for about 50 feet down, was lined with a six-inch iron tube, but from that on down to the depth of 382 feet it was bored without tubing. The material in which the well is bored is all earthy, and not rock, with a possible exception of two layers, each a few inches in thickness, which the workmen thought hard enough to be called stone. The boring was opened by raising and dropping a heavy iron rod with a chisel or drill-pointed end. When operating, the working up and down of this implement was carried on till the material was cut up and loosened for a foot or two down, when the rod would be withdrawn and a sand-pump put down in its stead, which was worked in the same way until it was filled with the loose material, when it was drawn up and emptied, and the drill put down again and more of the material loosened, to be taken out by the sand-pump, and so on till the water-bearing stratum was reached.

As the several strata were met, differences in the materials raised were very plainly marked, but from the way in which the boring was carried down without tubing, it was impossible to hinder some of the earth from the higher strata from being mixed with that in the part which was being worked, and so the changes could not be as sharply defined in quality or depth as they could have been in a tubed well. But from the records kept by the men who bored it, the following statement, of the materials passed through, is prepared :

- 18 feet—Sand and gravelly earth.
- 30 " Black clay, for 12 feet.
- 69 " " " and grains of green sand, 10 feet; black clay, 34 feet.
- 82 " Lighter colored clay and grains of green sand.

92 feet	Light colored clay, 4 feet, and pure greensand grains.
102 "	" " " " 2 feet, and fine-grained stone, light colored.
110 "	Clay, light colored, and plastic.
132 "	" ash colored, and flaky.
146 "	" " " with fragments of light colored stone.
155 "	Light ash colored clay.
177 "	Darker ash colored clay.
185 "	Black clay, coarse and free from mica.
195 "	" " micaceous.
210 "	" " " " fine.
229 "	" " " " "
241 "	" " " " coarse and rough.
268 "	Sand, compact and greenish.
280 "	Broken shells, fragments of <i>Terebratula Harlani</i> .
300 "	Grains of greensand and few shells.
303 "	Dark greenish clay, compact.
322 "	" " " " sandy.
337 "	" " " " "
360 "	Greensand and calcareous earth.
382 "	" " grains, open sand and <i>Belemnitella mucronata</i> .
397 "	Petrified stratum, 1 foot thick.
404 "	Clay, for the last 6 feet.
420 "	Open sand, for last 16 feet.

But little water was met until a depth of 382 feet was reached, when the water rose to a height of 18 or 20 feet above the surface. At this depth a four-inch tube was put in the well and properly set, so as to hinder any loss by leakage around the tube, and also to shut out any surface water that might otherwise find its way down the outside of the tube.

When the tube was fixed in its place the drill was again put down, the sand and earth was stirred for 38 feet further, and several cubic yards of sand were taken out. The water, in this way, was much increased in quantity, and it rose to a height of 28 feet above the surface.

The water which flows from the well has a temperature of 60° Fahr., is clear and colorless, and contains 8.5 cubic inches of carbonic acid per gallon. An analysis of the water, made by Prof. F. A. Wilber, shows it to contain 8.19 grains of solid matter in one gallon (58,333 grains), of which the following are the component parts:

ANALYSIS.

Sodium	0.274 grains.
Potassium.....	0.510 "
Calcium	1.520 "
Magnesium	0.286 "
Silica.....	0.682 "
Alumina and Oxide of Iron	0.402 "
Chlorine.....	0.449 "
Sulphuric Acid (SO ₃).....	1.540 "
Oxygen in Calcium Sulph.....	0.205 "
" " " Carb.....	0.404 "
" " Magnesium Carb.....	0.186 "
" " Potassium Sulph	0.104 "
Carbonic Acid (CO ₂) in Calc. Carb	1.115 "
" " " Mag. Carb.....	0.512 "
<hr/>	
Total Solids found.....	8.189 "

These constituents are probably combined as—

Sodium Chloride.....	0.706 grains.
Potassium Sulphate.....	1.188 "
Sulphate of Lime	1.728 "
Carbonate of Lime	2.530 "
" Magnesia	0.976 "
Chloride of Magnesium	0.029 "
Silica	0.682 "
Alumina and Sesqui-oxide of Iron.....	0.402 "
<hr/>	
Total Solids.....	8.191 "

The amount of solid matter in the water is so small that it is properly classed as *soft water*, and the quantity of iron in it is so little that it does not produce any discoloration.

As would naturally be expected, there is no organic matter in it, and it is entirely free from contamination by surface impurities.

The depths at which the various geological strata were met in boring this well, give proof of the regularity of the geological structure of the southern part of New Jersey. They show the occurrence of the several beds of marl, with their intermediate beds of other materials, in the same order that they occur at their outcrop, which is some 10 or 15 miles farther to the northwest. They also yield the same characteristic fossils—thus, the *Belemnitella mucronata* is found in the Lower Marl bed here as well as in the surface marl pits, and the

Terebratula Harlani, so peculiar and well marked a shell found in the Middle Marl bed, is also found in its proper place in the marl in this well.

The greater distance between the outcrop of the Lower Marl bed and its occurrence in the well has given an opportunity to determine the dip of the strata with more accuracy than we have been able to determine it heretofore. The longest outcrop in the direction of the dip which we had heretofore got was from Middletown to Red Bank, a distance of $4\frac{1}{2}$ miles, and this gave the dip of 37 feet per mile. We now have the whole distance from Middletown to the well, which is $14\frac{3}{4}$ miles, and the marl at the former place is 170 feet above tide-water, and at the latter place it is 370 feet below the tide. This gives a descent of 540 feet in $14\frac{3}{4}$ miles, which is 36.6 feet descent per mile. And in the same way the Middle Marl bed is 305 feet above tide-water at Big or Crawford's Hill, and at the well, which is 16 miles from it, the same marl bed is 280 feet below tide-water. This gives an average dip of 37 feet per mile.

The upper layer of the Upper Marl bed was not marked, in boring the well, with sufficient accuracy to determine its exact depth beneath the surface, but all our observations hitherto have led us to the conclusion that it dips about 25 feet per mile towards the southeast. And from lack of information to the contrary we have inferred that the several beds of marl were parallel to each other, and that their dip diminished in going towards the southeast. The well boring has shown that the middle layer of the Upper Marl bed is much thicker at that place than it is at its outcrop, and that the upper and middle layers of the Upper Marl bed are not conformable to the lower layer of that bed or to the other marl beds. The Lower and Middle Marl beds belong to the Cretaceous Age, while the upper layer of the Upper Marl bed is of the Eocene Age. And the two beds are unconformable, as has been found to be the case generally in other countries.

In our report for 1882 we gave the depth at which water-bearing strata might be expected to occur, at various distances to the southeast, from the outcrop of the marl beds, and recommended the sinking artesian wells. The result of this boring is to show that the water-bearing stratum which supplies Ocean Grove is a bed of open sand, which we have formerly described as *Sand Marl* and which is immediately under the Lower Marl bed. It is about 20 feet lower than we hoped to find the water.

As the Lower Marl bed dips 37 feet per mile, while our calculations were for a dip of only 25 feet per mile, which is the dip of the Upper Marl bed, the well is deeper than we calculated for, and should the dip of the Middle and Lower Marl beds continue the same as they have thus far proved to be, and the same water-bearing stratum has to be reached, then wells will be deeper than was calculated for last year. But the character of the strata of sand and marl found in the boring is so well marked, and so completely like that at the surface, that they give strong encouragement of their continuance to distances still farther away from their outcrop, and a reasonable expectation that they will yield water for the supply of all the towns and villages along the sea-side.

ARTESIAN WELL AT ASBURY PARK.

Since the completion of the well at Ocean Grove, Mr. Uriah White, of Asbury Park, has sunk an artesian well at that place, and, at the date of this report, it is just down, and is sending up a fine flow of pure water. The well is located on Mr. White's lot, about 300 feet from the depot, and 3,276 feet northeast from the Ocean Grove well. This distance, however, is oblique to the line of dip, and by making proper allowance for this oblique measurement it is found that it is only 2,316 feet farther up on the sloping stratum than the former well is. As the dip of the stratum is near 37 feet per mile, the well at Asbury Park should not be as deep as that at Ocean Grove by 16 feet; and, further, as the ground at the latter is four feet higher than at the former, it follows the measurements taken from the surface at Asbury Park well should be 20 feet less than those at the Ocean Beach well.

The well at Asbury Park is lined with an eight-inch wrought iron pipe to the depth of 372 feet, and is bored 21 feet in the earth beyond the tubing.

The same quality of materials was passed as in the first well. The layer of shells containing *Terebratula Harlani* was reached at the depth of 270 feet, and continued seven feet with a considerable body of greensand marl under it. At 365 feet sand was met with fragments of *Belemnitella mucronata*, *Exogyra costata*, *Gryphea convexa* and *Ostrea falcata*.

At 378 feet the sand was very solid, and continued with three feet

of very hard material and then about 10 feet of very loose sand almost like beach sand.

This second well gives a confirmation of the continuity of the water-bearing stratum, and it is hoped will lead to the boring of many more along the shore. The value of a supply of pure water such as these wells afford can hardly be over-estimated, and its sanitary benefits will lend another attraction to numerous health resorts along our sea-shore. The water is absolutely free from contamination with organic matters, it is soft enough for laundry purposes, and trial proves that the minute quantity of iron in it cannot be seen in the clothes washed in it, any more than it can in the pure and limpid water which flows from the wells.

IV.

THE RED SANDSTONE AND TRAP-ROCKS.

The report of last year contained a good deal of matter upon these rocks, and the subject might, perhaps, be left to some future and concluding report. But there are so many perplexing questions connected with the geological origin and condition of these rocks, that it becomes profitable to us to inform intelligent observers of the condition of the work, and to ask their co-operation in collecting and digesting the facts which may help to bring a correct solution of the difficult questions.

During the year, Prof. W. M. Davis, of Cambridge, Mass., has published a paper "On the Relations of the Triassic Traps and Sandstones of the Eastern United States," in which he has given a list of 67 writers who have prepared papers on the subject, and has given a resume of the conclusions reached by many of them. He has also given his views as to the time of the origin of the trap-rocks, considering that while some of the mountain ridges of trap are manifestly intrusive, and have forced their way up between the layers of red sandstone, that others were overflows; that is, that they were poured out upon the surface of the red sandstone while it was in process of deposition, and that after this overflow of trap other layers of sandstone were deposited upon the cooled surface of the trap. He considers the Bergen Hill and Palisade range of trap to be clearly intrusive, but is doubtful in regard to the first and second ranges of the Watchung mountain, and is inclined to consider them *overflows*. He thinks that in intrusive traps the sandstone and shale rocks are changed, "baked," as it were, by the heat of the melted trap, while in overflows the upper surface of the trap, from cooling in the open air and without pressure, is light and full of amygdaloidal cavities, and where any sandstone or shale overlies it these overlying rocks show no signs of having been heated or in any way changed.

Our own observations lead us to the conclusion that the trappean rocks, whether in the form of dikes or of mountain ridges, are all of a later age than the red sandstone and shales in which they occur, and that they were intruded after these sedimentary rocks had been elevated to their present inclined position.

The trap-rocks, when found in the long mountain ridges, have the appearance of great sheets or layers of trap interposed between the beds of sandstone. They are not, however, exactly true to the beds of sandstone, but in some instances they vary from the lines of bedding, splitting the layers a little higher or a little lower, as the case may be, and this is the strongest and plainest evidence of their intrusive origin. When the Triassic rock, in contact with the trap, is a pure sandstone, it does not show any marked change in color or appearance from its nearness to the melted rock. The Haledon quarry, of which a view is here given, has the trap in contact with the sandstone, and yet the sandstone is unchanged. The rock in the quarries at Paterson also is not materially changed. At Little Falls the sandstone is seen close under the trap, and even in the shaly beds is unaltered. And at many points in the First and Second ridges of the Watchung mountains the sandstone can be found apparently unchanged, and near the trap. But when the Triassic rock is a shale it shows decided changes by the action of the heated trap. That near Davison's Mill, on Lawrence's brook, six miles southwest of New Brunswick, has changed to a hard, black, smooth-grained and flinty slate. That near Griggstown copper mine has changed in color to a dull gray with a slight crimson tint, and in structure it is somewhat harder, and numerous spherical nodules of about the size of peas are developed in it; these nodules when broken across having the appearance of fine crystals of hornblende, radiating from the center. At Lambertville, on the Delaware, a portion of the shale has been changed in color so much as to show only the faintest tinge of its original red color, and in substance it is much harder and has developed in it numerous nodules of epidote, which are radiated in structure and from an inch to two inches in diameter. Near the same place, but in a different stratum, the shale has become of a light slate color, and crystals of black tourmaline in great numbers have been formed in it. These crystals are very short, being generally not more than a sixteenth of an inch in length, though they are from an eighth to a half inch in diameter, and with perfect terminal faces. At Weehawken, near the

Erie coal depot, where the trap has burst up through the layers of shale, the latter has been changed to a hard, faintly reddish rock of fine grain, and one very little changed by atmospheric influences. Boulders which have been torn from it are mixed in with the trap boulders from the hill, and are scattered over some of the vacant lots back of Jersey City. On the western face of the Palisade range, on the road from Alpine to Closter, the red shale has become hard and flinty without undergoing very much change in color, perhaps a little darker than its usual color when in its ordinary soft state. There is also an exposure of altered rock at the station Homestead on the Northern Railroad of New Jersey. The shale on almost the whole of the northwest slope of Sourland mountain is changed in color and hardness, so as to be recognized as *indurated shale*. On the northeastern slope of the First Watchung mountain, and about two miles southeast of the village of Pluckamin, the altered rock is also to be seen. It is also seen at the old Field copper mine, near the northwest foot of the same mountain. There is another locality still farther northeast, on the northwest slope of the same mountain, about a mile northeast from the gorge through the mountain back of Plainfield. The altered rock here has taken on a somewhat different appearance. There are some thin beds in it here which are calcareous, and the changed rock has put on something like the appearance of a marble approaching a serpentine—a singular and very variable rock.

In the old copper mines at Belleville the shale is indurated and the sandstone much whitened by the large tabular masses of trap which have been intruded between the layers of Triassic rock.

The occurrence of amygdaloidal or cellular trap is not decisive. It is evidence that there has not been much pressure upon the rock to solidify it, but in some cases it is also plain that such rocks are very near the original surface where the trap had risen entirely through the

NOTE.—The view at Haledon quarry shows the bedded sandstone in the foreground, and at the bottom and above it the wall of trap-rock rising to the surface of the ground. On the right-hand side, and in line with the derrick, the sandstone is split up into thin, rectangular plates by vertical joints at right angles to the plane of bedding. A fault of about four feet traverses the rock in this direction, but is not so well exhibited here as on the extreme left and beyond limit of our view.

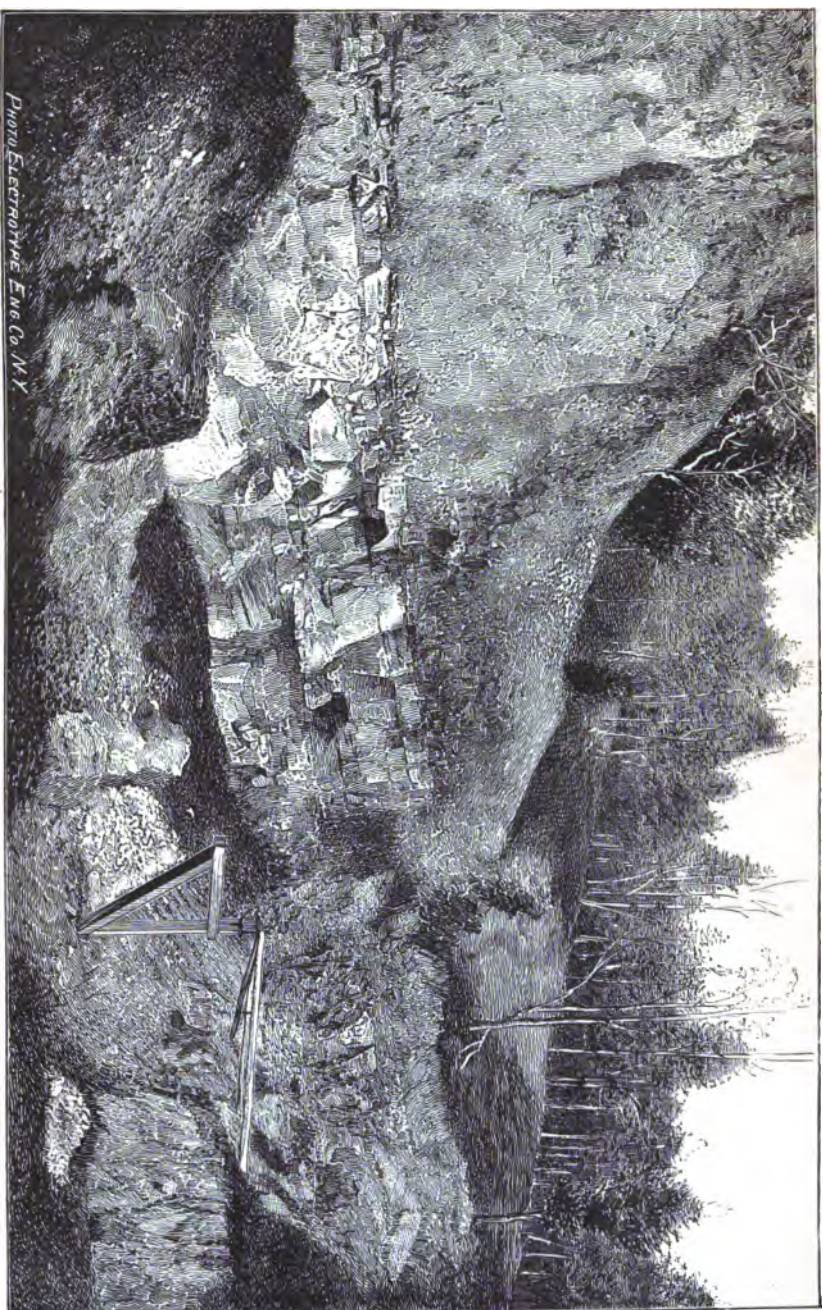


Photo Electrotype Eng. Co. N.Y.

VIEW SHOWING THE MEETING OF SANDSTONE AND TRAP-ROCK IN QUARRY AT HALEDON, PASSAIC COUNTY.

sandstone to the open air, and it may have been so in the other cases. In the First of the Watchung mountains, while there is much cellular trap near the top of the mountain, there are highly altered or baked shales on the northwest slope, near the base of the mount, of which three cases have been already cited. The singular curved form of almost all the trap-ridges, with their convex sides towards the southeast, is such as would be expected from a vertical force pressing against an inclined stratum of rock. It is remarkable that in the New England Triassic, where the strata dip towards the southeast, that there the curved form of the trap-ridges, which is quite as marked as in ours, is so as to present their convex sides towards the northwest. But many more facts are desirable before any theory will be absolutely proved.

The Triassic rocks have not been subjected to the powerful disturbing agencies which have bent or folded the strata of the older rocks. They are found fractured in many places, and a few faults of limited extent have been detected. The rock is so uniform in color and structure, and wherever exposed it is so rapidly disintegrated that faults in it are not easily detected, or easily traced when they are detected. They would furnish the simplest explanation of some of the peculiarities of the formation if they could be traced out, and much labor has been expended in the search for them, but with only moderate success. The accompanying view in a quarry at Haledon shows a fault of five or six feet, and the remarkable breaking up of the thick beds of sandstone by numerous vertical fractures or intermediate joints. Another fault in the red sandstone at the end of Garrett Rock, near Paterson, is very plain, and has been described by Mr. Davis, of Cambridge, this year. A fault in the sandstone at the Belleville quarries was figured in our report last year, and one in N. Y. & Greenwood Lake Railroad cut, at Arlington, was described in the report of 1882.

In the shallow rock cuts on the Easton and Amboy Railroad, near Sidney Church, in Hunterdon county, there are considerable disturbances in the strata and more curved layers than we have seen exposed anywhere else in the State.

The hypothesis was suggested in last year's report, that after the "deposition on a very uneven bottom, the underlying rock has been disturbed by a number of axes of elevation, or else of great faults, which have crossed the formation obliquely, but in a direction much nearer north and south than the general trend of the formation."

The occurrence of the long outcrop of Silurian limestone in the middle of the Triassic rocks at New Hope, opposite to Lambertville, on the Delaware, was cited as favoring this view; and the occurrence of the coarse, light-colored sandstones in a portion of Hunterdon county, and in range with the limestone, was further cited, with the fact that these sandstones are almost identical with those bordering the limestone in Pennsylvania, and those bordering the gneiss rocks near Trenton. A considerable tract of country in the valley of the Raritan has the sandstone dipping easterly, also as if conformable to some axis nearly north and south. Prof. J. D. Dana, in the *American Journal of Science*, in remarking upon this hypothesis, considers it to need more facts before it can be received as settled truth. And they are undoubtedly needed before it can be accepted as correct.

Mr. Nelson H. Darton, a chemist and geologist, from New York city, has been devoting much labor to some of the questions connected with the trap and sandstone, especially that of the Palisade range. His papers in the New York Academy of Science, as well as his letters to the Survey, are very instructive and suggestive.

As new exposures of the rocks are made in railroad cuts, mining explorations, or other works, we are looking for other evidence of faults, and from them of answers to the questions which now trouble us.

These points are given even in this incomplete and unsatisfactory form, with the hope of awakening interest and inquiry among those living on the debatable ground, and getting a larger number of persons observing and recording facts. It is in this way that we may reasonably hope to more quickly secure needed information.

V.

ARCHAEAN ROCKS AND IRON ORE.

GEOGRAPHICAL EXTENT AND SURFACE FEATURES.

The Archaean rocks outcrop in the mountainous region of the northern part of New Jersey. The same mountain range is known in New York as the Highlands; and it is crossed by the Hudson river between Fishkill and Peekskill, and by the Delaware between Marble mountain and Johnson's Ferry. For convenience, the name of Highlands is here retained for the New Jersey portion of the chain. It runs southwest into Pennsylvania, and there goes by the name of the South mountain. Its breadth on the New York line is 22 miles; on the Delaware, 10 miles; and its length about 60 miles. The area of the whole belt, with the included beds of limestone, slate and sandstone of newer formations, is about 900 square miles; that of the Archaean rocks proper is estimated at 770 miles. The range consists of many ridges which are in part separated by deep valleys and in part coalesce, forming plateaus or table lands of small extent. Some of the included valleys are quite as deep as the red sandstone plain on the south and the Kittatinny valley on the north and west. The ridges stand in a sort of en échelon position, one sinking down and another rising up and succeeding it. And these ridges trend more nearly north and south than the course of the range as a whole. The valleys which separate them, when followed, are found to open out into the country on the northwest and to the southeast. The valley of the Ramapo river in New York; that of the Wanaque creek in Passaic county; German valley; the valley of West Milford and Greenwood lake; the Vernon valley; the valley of the Wallkill; the Musconetcong; the Pohatcong and the Pequest valleys are all illustrations of these peculiar features. Of the ridges in this range, the most prominent are the Ramapo mountain, Trowbridge and Watnong

mountains on the southeast border ; Wawayanda and Hamburg mountains, Schooley's mountain and Musconetcong mountain in the central part ; and Pochuck mountain, Pimple hills, Jenny Jump mountain, Scott's mountain and Marble mountain on the northwest side. There are many others of equal elevation, but not so long nor so prominent in the scenery of the region and which lack names excepting such as are of exceedingly local nature.

A characteristic feature is the absence of what might be termed Alpine structure or scenery. There are no prominent peaks or cones. The ridges are even-topped for long distances, and the average elevation is uniform over wide areas. Looking at the crests alone and imagining the valleys and depressions filled, the surface would approximate to a plane gently inclined toward the southeast and toward the southwest. The descent or dip to the southeast would be greater than that to the southwest. The mean altitude of the ridges on the southeast border, of the crest line of the Ramapo belt, is, in round numbers, 1,100 feet at the northeast and 800 feet at the southwest, a slope toward the southwest at a rate of about 12 feet per mile. Looking at the northwest crest line of the Musconetcong belt and west of the center of the Highlands, the altitude ranges from 1,400 feet in the Wawayanda mountain, at the northeast, to 900 feet in the Musconetcong mountain, near the Delaware river, equivalent to a descent of 10 feet per mile. The differences between the heights of this crest line and that of the southeast border would give various rates of descent, from 20 to 35 feet per mile. The crest line in the northwest, passing through Pochuck mountain, Pimple hills, Jenny Jump mountain, Ragged ridge and Marble mountain, does not show a uniform descent to the southwest, as the elevations of Pochuck, Pimple hills and Jenny Jump are each on an average from 1,000 to 1,100 feet. Ragged ridge declines to 800 feet and Marble mountain to about 700 feet. It may be noted that these figures of descent to the southeast border from the northwest-central parts of the Highlands are little less than the rate for the Cretaceous and Eocene beds in the southeast and southern parts of the State. Reference to the forthcoming topographical sheets, Nos. 3 and 4 of the new atlas of the State, will show how remarkably even-topped these ridges of the Highlands are, and enable the reader to construct for himself the plateau indicated here by these crest lines. The steeper southeast slopes are also apparent on studying the topographical maps. This feature is more fully

referred to in the discussion on geological structure. The existence of plateaus or table lands also is demonstrated by the contour lines of the topographical survey. The more prominent and larger of these high levels are, the country south of Dover and east of German Valley, Schooley's mountain range, Scott's mountain and the country from Lake Hopatcong, extending northeast through Sussex and Passaic counties to the State line. They are not to be understood as level, but as diversified by the ridges which rise from 100 to 300 feet above the deepest depressions, the latter being 400 to 600 feet above the adjacent valleys and plain country. Once upon them the so-called mountains disappear and sink into hills, whereas, when viewed from the valleys, the plateau or table land rises up as a mountain. And hence the origin of many of the names by which the various ridges are known. Near the valleys the apparently lofty ridges are designated as mountains; in the ridges, away from the valleys and outside plain country, names are often wanting for even the highest crests, as they are called hills.

The highest point in the Highlands of New Jersey is near the Williams mine and two and a half miles due south of Vernon, Sussex county. Its height above the ocean is 1,496 feet. Another point of about the same elevation—or a few inches only, lower—is near Sand pond, and two miles southeast of McAfee valley. Both points are in the Wawayanda-Hamburg range. The greatest depression in the range is where the Delaware river crosses it, from Marble mountain, north of Phillipsburg, to Holland station. The ordinary level in the river at Marble mountain is 167 feet. The Central Railroad of New Jersey and the Warren Railroad cross it in a gap of 637 feet. The Morris Canal summit and the Delaware, Lackawanna and Western Railroad is 916 feet. The highest point on the line of the New York, Susquehanna and Western Railroad is 1,032 feet. The New York, Lake Erie and Western Railroad crosses the Highlands a few miles north of the New Jersey boundary, and its summit is 514 feet. And, lastly, it should be stated that the Hudson is a tidal channel cut through the whole range.

A characteristic feature of the topography in the northeast portion of the New Jersey Highlands is the inequalities in the slopes of the subordinate ridges descending to the northeast and the southwest. The former are long and gentle, while the latter are short and steep. This peculiarity in the surface is exhibited by diagrammatic sections

of typical hills and regions shown in a figure on a succeeding page of this report. The study of the maps will enable the reader to find many examples in addition to those there illustrated.

The surface of the Highlands is partly explained by its structure and partly by the fact of the glacial drift, which covers more or less of the ridges and fills many of the depressions and valleys deeply. The southern limit of the great continental terminal moraine was described in the annual reports for 1877-1881. In the latter report, notes describing the surface accumulations of this drift were given. In general, it may be said that, north of the terminal moraine, the outcropping ledges of rock are in nearly all cases hard, firm and rounded or polished by glacial action. The aggregate area of exposed rock surface is large, as outcrops are numerous in all parts. In the hollows and lower parts of the district the drift and the alluvial accumulations of earths and sandy clays, washed from the hills, and peaty growths conceal the rocks. This part of the Highlands is remarkable for its numerous lakes and ponds, all of which owe their origin to drift or to glacial agency. The country south of the terminal moraine has no lakes in it; and the ponds are small and nearly all of them are artificial reservoirs of water. The Highlands south of this moraine limit are distinguished by the disintegrated and *weathered* condition of the gneissic outcrops. There are exceptional localities where the rocks are hard, but not altogether unaltered. Generally, the *weathering* or alteration can be observed to a considerable depth. In some of the mines the rock is friable, and can be broken up by a pick at a depth of over 100 feet beneath the surface. Alterations to depths of ten to thirty feet are common. The surface earth is not the mixed debris of distant ledges and formations, but the material from the rock thus disintegrated and fallen to pieces. In places, local washes or drainage of slopes has apparently mixed the materials to some extent. As a consequence of this weathered condition of the rocks near the surface, the country south of the glacial drift line is marked by its adaptation to purposes of tillage, and the area in farms and under cultivation is much greater, proportionately to the whole surface, than it is north of the terminal moraine, where the numerous ledges and the bowlders of the surface make neat tillage almost impossible without much labor and expense in their removal. Another marked distinction is in the more regular and uniform slopes in the driftless parts of the Highlands. The slopes are dip-slopes, or the

natural slopes resulting from drainage which has been determined by the structure. In the glacial drift-covered areas the slopes may be very irregular, and the drainage has been modified greatly by this drift.

In the Highlands there are some outcrops of rocks newer than the gneisses, granites and other crystalline rocks, which attain elevations and make ridges equal to those which may be properly classed as parts of the Highland range. In some of the valleys, the slate ridges are prominent features of the surface. But the most prominent are the Bearfort or Rough mountain, Kanouse mountain, Copperas mountain and Green Pond mountain. These ridges constitute a belt which extends from the New York line southwest to Succasunna Plains. They are very rocky, and have steep slopes; and they are of about the same height as the gneiss on each side of them. They are recognized in the landscape as wanting the softer and more rounded lines of the gneissic ridges, and are also distinguished by their more scanty tree covering and absence of any signs of tillage or farming lands. They do not properly belong to the Highlands of the Archaean age, as their strata lie unconformably upon the tilted gneisses; and the latter were thus upraised and folded long before these sandstones, siliceous conglomerates and arenaceous shales were deposited. Later changes of level and glacial action have been common to both of them and the older strata on which they repose.

For complete illustration of the various features of the surface configuration, reference must be made to the topographical maps of the Survey, which now cover all of the Highlands.

ROCKS.

The rocks which make up the Archaean Highlands of New Jersey are metamorphic or crystalline. They include granite, syenite, gneiss in its several varieties, crystalline limestone and magnetite. Besides these more common rocks, there are other species of limited extent and rare occurrence. Mica-schist, hydromica-schist or slate, hornblende-schist and serpentine are among the species more rarely seen. Two varieties of gneiss constitute a large part of the whole area of outcrop. They are the feldspathic, and the hornblendic or syenite-gneiss. The rocks are generally plainly crystalline in structure, varying from coarse to fine, according to the size of the com-

ponent minerals. Aphanitic, or microscopic structure, in which the minerals cannot be determined without the aid of the microscope, is rare. The minerals are often arranged in parallel lines or thin layers, and the mass sometimes has a laminated structure due to this arrangement. In some cases it is the clue to the stratification where the bedding planes are indistinct or wanting through masses of considerable thickness. The feldspathic gneiss is marked by the feldspar, its most abundant or predominating mineral. Orthoclase, or the potash feldspar, is the common mineral species, with oligoclase and albite as accessory species. And according to the nature of this constituent, the rock varies in appearance, texture and firmness. The great degree of disintegration and decay in places is owing to the oligoclase in the mass. The quartz is in the form of flattened grains up to half an inch in length; of white or bluish white shade, and translucent to opaque. Mica is rarely altogether wanting, though often in small quantity. It is often found in very thin layers or laminae, and makes the stone split readily in the plane of these micaceous layers. Generally it is in scattering thin scales, and altogether subordinate to the feldspar-quartz mass. It approaches the species of granulite, but does not quite answer to it, as the mica is present in more than traces. This variety of gneiss weathers in its outcrop, and produces a gray, grayish white and quartzose or sandy soil of a somewhat open and porous nature, which is characterized by its forest growth of chestnut timber.

The hornblendic gneiss, or syenite-gneiss, is not so common as the feldspathic variety. In it the hornblende appears as the principal mineral constituent, and gives character to the rock. Feldspar is also present, but the quartz and micas are subordinate in quantity. There are many gradations; and a common type rock is that wherein the hornblende and a dark-colored mica predominate, while the feldspar is in scattering crystalline grains and quartz almost altogether wanting. This variety grades by the accession of hornblende into a hornblende-schist or hornblende rock, and by the mica coming in to replace the hornblende into mica-schist. These hornblendic varieties of gneiss are generally dark colored and finer crystalline than the feldspathic gneiss. They also weather, and, by their decomposition, produce the dark-red to brown soils so often observed in the Highlands. It is not so sandy and open, but more clayey and closer than the feldspathic soils. Its forest covering is more of a mixed character. Oaks flourish with the chestnut, or the latter is not common.

Granite and syenite form dykes in places as well as veins which traverse the bedded gneisses. Trappean rocks also occur at a few localities in narrow dikes, but their lithological properties have not been studied.

White crystalline limestone forms outcrops over long belts in the northwest part of the Highland range, particularly in the Vernon valley, and thence southwest to Sparta. It is found at isolated points in the southeast or Ramapo belt also, and there it is associated with serpentine. The limestone of the northwest or Pequest belt is seen at several localities stratified with the gneisses conformably. In structure, this rock varies greatly from fine grained, or amorphous, to coarse crystalline. In color, also, it ranges from white to flesh-red, pink, variegated and black, or very dark color. Its chemical composition is that of pure carbonate of lime, but varying to dolomite or magnesian.

The division of these Archaean rock outcrops into belts or groups, according to their specific characters, has been attempted, but thus far without complete success. Following the analogy of the newer formations, it ought to be possible to define the limits of well-marked varieties and describe their outcrop. The division following the feldspathic and hornblendic varieties appears possible, as their outcrops are so easily recognized by the rock, soil, structure and even flora. Many lines have been followed in hope of detecting some order in the succession or alternation of these more common varieties of rock. The results of these observations in the field may be generalized as follows:

1. The feldspathic gneiss, in thick beds generally, predominates in southeastern and central parts of the Highland range.
2. The hornblendic or syenite-gneiss is conspicuous in the northwest belt of the formation, particularly in the central cores and higher parts of its ridges.
3. The gray, feldspathic variety appears more prominently upon the flanks and at the base of these ridges.
4. The hornblendic and the micaceous gneisses are often found accompanying the magnetic iron ore beds, and more commonly on the southeast or hanging-wall side of the ore, the foot-wall rock being of gray gneiss quite as often as of the darker-colored, hornblendic and micaceous gneisses.

The former provisional division of the Highlands into the four

belts, running from northeast to southwest, is retained on account of convenience for reference. They are known as the Ramapo, at the southeast; then the Passaic next, to the northwest; then the Musconetcong, and, lastly, the Pequest. Their boundaries have been described in previous reports of the Survey.

A complete lithological examination of the rocks already collected and additional field studies, aided by the new topographical maps, will no doubt lead to some better and natural division and confirm some of the positions here indicated.

MAGNETITE, MAGNETIC IRON ORE.

Magnetic iron ore occurs in beds conformably to the gneissic rocks, and, therefore, it is placed in a description of the rocks of the Archaean formation of our Highlands. It may be made up of magnetite alone, but when found to any extent as a bed of workable size, it consists of magnetite mixed with feldspars, quartz, hornblende, augite, micas, garnet, calcite, pyrite, apatite, or more rarely with other minerals. Some one or more of the above-mentioned minerals are always present and more or less affect its richness and quality. *Magnetite* may be said to be distinguished by its being attracted by the magnet, black streak, black powder when crushed, and its octahedral form of crystallization. Its specific gravity ranges from 4.9 to 5.2, and hardness is nearly equal to that of ordinary feldspar. Its composition is 72.4 per cent. of metallic iron and 27.6 per cent. of oxygen. Hence the richest ore cannot yield more than this percentage of metal. The ore often has a granular structure owing to the blending of its crystalline components, and, as these vary in size, it is said to be coarse granular or fine-grained to massive. Magnetite occurs also as a constituent mineral of the gneissic and syenitic rocks in many localities in the Highlands. In fact, it is found in all the varieties of our crystalline rocks, though not so generally diffused as to give character to the species. It is to be regarded as an accessory, and not as an essential constituent. It does, however, in some cases replace some one of the ordinary or common constituents. When this replacement by magnetite is sufficient to raise the percentage of metallic iron to the limit where its extraction becomes possible at a profit, the rock may be considered as an ore. As this limit is not sharply defined, but is shifting from time to time, according to the demands of the market, cost of

extraction and other industrial factors, the same bed may be viewed as a rock or as an ore at different periods. From the geological standpoint all are rocks. It has happened again and again that rocks containing less than one-half of the volume of magnetite have been worked as ores. And in some instances highly ferruginous minerals with the magnetite have also contributed to enrich the mass and so increase the iron as to allow of its being worked as an ore. The line of demarcation between ore and rock, is, therefore, not fixed. Practically, only the strata wherein magnetite is the predominant mineral should be ranked as ores of iron; those in which it is subordinate in quantity, or an accessory constituent, must be placed in the list of rocks as distinguished from ores in an economical point of view.

In following the magnetic iron ore beds, the replacement of magnetite by the common gneissic minerals, quartz, feldspar, hornblende or mica, is often observed. In frequency of occurrence the replacement by some of the hornblendic varieties of rock is first, the feldspathic gneisses rarely appearing in this way. This replacement may be by degrees, and the ore grade into rock or it may be a sharp change from one to the other. And in rare occurrences the rock thus coming in place of the ore contains no apparent traces of magnetite. In practical operations of mining, the ore is sometimes said to be "cut out by rock." Careful examinations of such localities have frequently proved a replacement, the stratification being continuous and undisturbed. Generally the ore is found to become lean gradually and at last to be no longer workable. The beds continue carrying a considerable percentage of magnetite with their other constituents. This gradation from ore to rock is traceable not only in the same bed, or on the line of strike, but also from bed to bed, and in many cases the walls contain more or less magnetite. In fact, the beds which are left as *walls* may at another time be removed and smelted for the iron they contain. In far the greater number of mines, however, there are clear, well-defined rock walls which limit the ore and the mining operations. So, too, the ore beds more often thin out in pinches and do not grade into rock when followed for great distances.

As already described, the magnetic iron ore beds partake with the associated gneissic strata of all the essential and accidental features or elements belonging to stratified rocks. They possess dip, strike and pitch and are folded, faulted and pinched as other rocks about them. Lamination, cleavage and jointing are also observed, though much

more rarely. Hence, when viewed in connection with the associated stratified rocks the conclusion is unavoidable that they were deposited as sediments and are of the same age with them.

At a glance it might be supposed that the ore beds differed from the rocks about them, in their much more limited outcrops and extent. So far as the total thickness of the gneissic strata are concerned the comparative size of the ore beds becomes almost insignificant. But it should be remembered that in this series of crystalline rocks there are many varieties which differ greatly from one another and the unbroken or continuous succession of strata having the same composition can nowhere be observed for a long distance or over wide areas of outcrops. Again, nearly all of our larger mines continue to work upon the same apparently inexhaustible *vein* or ore beds. At Hibernia, for example, the total length opened is over a mile long. The long lines from Irondale to Mount Hope may yet be proved to be parts of one formerly continuous sheet of ore, greatly disturbed by faults and pinches. The Chester mines also appear to be upon a well-defined and characteristic range, or, perhaps, narrow belt of ore and ore-bearing beds interstratified with the ore. Hurdtown shows a shoot already followed nearly a half a mile. Rock strata having uniform characters and of equal extent cannot be said to be much more common.

The stratified or bedded structure is not, however, in many localities so apparent and in some mines it is not easily recognized. Instead of the ordinary features of stratification, irregularity is conspicuous and the ore bodies are of so irregular shapes as to be considered by some observers and miners as *veins* or huge dikes of ore, entirely distinct from the enclosing rock masses. They sometimes approach in shape the form of ore bodies, which in the West are known as *chimneys*. But the old notion that all ores come up from the depths of the earth and through fissures and between rent strata of rock, has obtained so firm a hold of practical miners that they are regarded as *veins* and not as beds. In these cases the original bedded structure has been almost obliterated by the subsequent changes it has undergone. In deference to popular usage the term *vein* is retained in many places in the descriptions of mines and of ore localities, but it is to be understood as denoting a bed of ore, and not, strictly speaking, a vein.

Magnetite occurs in unstratified rocks also. It is a constituent of

huge granitic and syenitic rock outcrops and dikes; and, in a few localities, it has been found to be in quantity sufficient to make mining profitable. They have been described in previous reports in connection with notes of mines and ore localities, and reference may be had to them. Magnetite may, therefore, be regarded as one of the ordinary constituents of both stratified and massive rocks of the Highlands. When it predominates in the composition of the mass to the exclusion of other minerals almost entirely, it becomes an ore. And it may occur in the form of a dike or massive rock, or in beds, interstratified with the gneissic rocks. It is an integral member of the Archaean rock series, whose history covers that of the magnetic iron ores as well as those of its associated rock species. And hence the great importance of studying not only the composition but also the structure of the whole formation in order to discover the laws of occurrence as they relate to iron ore and gneissic strata alike.

GEOLOGICAL STRUCTURE.

The Archaean rocks embraced within the limits of the Highlands, whose limits have been given in a preceding section, are, with the exception of comparatively small outcrops of massive granite and syenite, and lesser trappean dikes, all stratified.

For convenience of description, the various forms and positions of the strata, or what may be termed the elements of stratification, viz., dip, strike, pitch, folds, faults and pinches, are discussed under these special heads. The dip and strike are considered essential features; the pitch is common to this district; but the folds, faults and pinches are regarded as accidental, and not characteristic of the formation as a unit.

DIP.—Stratified or bedded rocks, including ores which are in beds, are rarely met with in a horizontal position. The original surfaces upon which their material was laid down were probably more or less sloping. And the subsequent uplifting and folding have, in nearly all cases, tilted them at various angles with the horizon. Two elements enter into the dip—first, the direction in which the bed is inclined, or the line of *greatest inclination*; and, second, the angle of the inclination or amount of the dip. The angle made by the plane of bedding with the horizon equals the amount. In our mining

districts the dip is often spoken of as the "underlay of the bed." When the strata are in a vertical position, or dip at an angle of 90° , the direction is wanting.

In the Archaean rocks of our New Jersey Highlands the strata are generally upturned at high angles, and, in many places, are seen standing on edge. The prevailing direction of the dip is in the southeast quarter or quadrant. Over wide areas, and on long section lines crossing the strata, this general direction may be observed with scarcely a single exception. The amount of the dip is also quite constant at high or steep angles, ranging from 45° to 80° . The numerous outcrops, often of considerable extent, give opportunities for observing the dip of the beds at the surface. The many railroad cuttings also afford long and beautiful sections where the position of the rocks is exposed to view. And lastly, the comparatively large number of iron mines and exploring pits and shafts in search of ore give excellent opportunities to study the structure at varying depths beneath the surface. Notwithstanding the many points where observations upon the dip may be made, there are wide gaps and large areas in all parts of the Highlands where they are not possible. North of the terminal moraine line the glacial drift conceals, in many places underneath thick deposits of earth, gravel and boulders, the rock surface or original outcrop. In others, the accumulations of a more recent age, in the form of stratified sands, clays, shells, marl and peat, hide the strata. Lakes and ponds in drift basins cover no inconsiderable portion of the total area. South of the terminal moraine, and, to a slight extent north of it also, the outcropping ledges have, in very many localities, become so disintegrated that their stratification is no longer apparent. The earth and soil covering resulting from the disintegration of the rocks at the surface also conceals the strata over very wide areas. And lastly, owing to the massive character of the rock, the bedding lines often are not visible, and the dip is made out by the structure of the rock in its mineral arrangement. This mode of determination is not always certain in its results, although so often it gives the only possible clew to the position of the strata. Of course, it must be evident that where the beds are somewhat irregular or uneven, the dip is ascertainable only through many observations and getting their average. The observations made in our Highlands in the course of the field work during several seasons have been tabulated geographically, following the

order of the belts into which it is divided. Beginning at the south-east, in the Ramapo belt, the observations are arranged from northeast to southwest; then the Passaic, Musconetcong and Pequest belts follow in order, and with their respective localities arranged in the same way. The localities are found in the first column, then the direction, and last, the amount or angle of the dip. Where the strata are vertical the strike is indicated. The bearings, as here given, are magnetic; and the initial letters for the quadrants are approximately 45° between the cardinal points thus indicated, *e. g.*, S. E. is $S. 45^\circ E.$, N. W. is $N. 45^\circ W.$ The abbreviation *st.* is used for steep, and it signifies angles exceeding 45° , and, in most cases, from 60° upwards. In a few instances, two angles and sometimes two directions are given where there is such variation in a very limited space.

TABLE OF DIPS.

Ramapo Belt.

LOCALITY.	DIRECTION.	AMOUNT.
Ramapo mountain, top.....	S. 50° - 55° E.	80°
“ “ western slope.....	S. 50° - 60° E.	80°
Freedomdale furnace site, ledges at.....	S. 55° - 60° E.	50°
N. Y. & Greenwood Lake R. R. cut, Wynokle Valley.....	S. E.	Steep.
Rheinsmith mine.....	N. W.	60°
Debow limestone quarry.....	S. E.	Steep.
Beam lot, northeast of Bloomingdale.....	E. S. E.	60°
Ryerson's quarry, Bloomingdale.....	S. 45° E.	50° - 60°
Old forge dam, “.....	S. 35° E.	Steep.
N. Y., Susquehanna & Western R. R. cut, near Bloomingdale.	S. 30° E.	70°
N. Y., Susquehanna & Western R. R. cut, $\frac{1}{4}$ mile east of } Bloomingdale..... }	E. S. E.	65°
One mile northeast of Pompton church.....	N. W.	80°
Ridge northeast of Pompton station.....	N. 55° W.	80°
Near above locality.....	Strike N. E.	Vertical.
“ “ a second point of observation.....	S. E.	80°
Near Slater's dam, Pompton.....	S. 55° E.	60° - 65°
N. Y., Susquehanna & Western R. R. cut, near Pompton.....	S. 65° E.	50°
Near last-named station.....	S. 40° E.	60° - 70°
West of Pompton, on N. Y., S. & W. R. R. line.....	S. 35° - 40° E.	65°
De Bow mine, near Pompton.....	S. E.

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TABLE OF DIPS—Continued.

Ramapo Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Brown place, near Pompton Plains.....	S. E.	70°
Kayhart mine.....	N. W.	65°
Vreeland ".....	S. E.	70°
Turkey Mountain limestone quarry.....	N. E. N. 50° W.	Steep. Steep.
Near White Hall, corner of road to Turkey mountain.....	E. S. E.	80°-85°
North of Montville.....	S. E.	Steep.
Asylum quarry, Morris Plains.....	S. 45° E.	35°
Morris Plains, west border.....	N. W.	80°
Headley place, northeast of Morristown.....	N. W.	Steep.
Morristown, road to Brookside.....	E. S. E.	.....
Mendham, on Morristown road.....	S.	Steep.
Connet mine.....	S. W.	40°, nearly vertical.

Passaic Belt.

Ringwood, Hewitt mine.....	S. E.	80°
" New or Wood mine.....	S. E.	88°
" New Miller ".....	S. E.	60°
" Peters ".....	S. E.	40°
" Blue ".....	Strike N. E.	Vertical.
" Hard ".....	S. E.	60°
Board mine.....	S. E.	30°
Near D. Cisca's limestone quarry, West Milford township.....	E. S. E.	40°
East of Gould's quarry, near Macopin.....	E. S. E.	15°
Tellington mine.....	S. E.	40°
Y. Y., Susquehanna & Western R. R. cut, 1¼ miles west of } Smith mills..... }	S. E.	Steep.
Hill, ¼ mile southeast of Charlotteburg.....	E. S. E.	60°
Quarry, southeast of Charlotteburg.....	E. S. E.	55°
Stony Brook mountain, Pequannock township.....	S. 50° E.	70°
West of Stony Brook church.....	N. W.	Steep.
Brown's shaft, west of Boonton and Bloomingdale road.....	S. E.	70°
Rockaway Valley mines.....	S. E.	50°-60°
Righter Mine.....	N. W.	Almost vertical.
Pike's Peak mine.....	S. 65° E.	60°

TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Taylor mine.....	Strike E. N. E.	.....
East slope of Lyonsville ridge.....	E. S. E.	Moderate.
At Lyonsville.....	S. E.	Steep.
West of Lyonsville, S. H.....	S. 80° E.	Moderate.
Splitrock Pond mine.....	S. E.	Very steep.
" or Cobb mine.....	S. E.	70°-78°
" furnaces, ledges in dam.....	W. N. W.	60°-70°
Beach Glen mine, northeast opening.....	N. W.	Very steep.
" " southwest " 	N. W.	Steep.
" " " " 	S. E.	Steep.
Hibernia (Willis) mine, surface.....	S. E.	81°
" " " 30 feet down.....	S. E.	78°
" (Upper Wood) mine.....	N. W.	Steep.
" " " " deepest slopes.....	S. E.	Nearly vertical.
" (Glendon).....	S. E.	86°
" brook, in adit tunnel.....	S. E.	60°
Beach mine, Hibernia.....	S. E.	80°
White Meadow mines.....	S. E.	75°
Mine holes, 1½ miles north of Rockaway.....	S. 60° E.	60°
Swedes mine.....	S. E.	50°
D., L. & W. R. R. cut, south of Rockaway.....	S. 45° E.	65°
Dover quarry, east of town.....	S. 42° E.	50°
" D., L. & W. R. R. Co.'s quarry.....	S. 45° E.	55°
" Central R. R. cut, (High Bridge Bra.).....	S. E.	55°
Charlotteburg iron mine.....	S. E.	.....
Kitchell tract, east of Copperas mountain.....	S. E.	38°-45°
West of Timber brook and near Copperas mountain.....	S. 45° E.	40°
Green Pond mines.....	S. 55° E.	35°-45°
" " southwest end.....	E. S. E.	30°
East of Davenport mine.....	E. S. E.	Nearly vertical.
East foot of Copperas mountain.....	E. S. E.	30°-45°
Near Green Pond brook, west of Denmark.....	S. 70° E.	Steep.
" " " " 	S. 65° E.	42°
Pruden's saw mill, south of Green Pond.....	S. 50° E.	70°
Hickory Hill deposits.....	S. E.	65°

TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Mount Hope.....	S. E.	65°-70°
" Teabo vein.....	S. E.	70°
" Sturgis mine.....	S. E.	75°-85°
" Elizabeth vein.....	S. E.	72°
Allen mine.....	S. E.	65°
Richards mine.....	S. E.	60°
Baker "	S. E.	80°
Dolan "	S. E.	45°
Mount Pleasant mine.....	S. E.	57°
R. R. cut, High Bridge Bra., Port Oram.....	S. 56°-60° E.	45°
King Hill, north end.....	S. 60° E.	55°
Johnson Hill mine.....	S. E.	40°
Randall Hill, northwest side.....	S. 85° E.	45°-50°
" " crest	S. 45° E.	80°
" " mine.....	S. E.	50°
Irondale, Hubbard mine.....	S. E.	80°-85°
" Sterling "	S. E.	45°
" Corwin "	S. E.	45°
Baker mine, on hill.....	S. E.	80°
King mine.....	S. E.	54°
Canfield mine.....	S. E.	50°
" " westernmost openings.....	S. E.	35°-40°
Canfield's phosphatic iron ore mines.....	S. E.	60°-70°
Dickerson mine (Big mine).....	S. E.	55°-60°
" " side vein.....	S. E.	Steep.
" " " near surface.....	N. E.	Moderate.
Bryant mine.....	S. E.	60°
Byram "	S. E.	50°
North of Dalrymple mine.....	S. 35° E.	60°
Dalrymple mine.....	S. E.	Almost vertical.
DeHart "	S. E.	80°
David Horton mine.....	S. E.	80°
George or Logan mine.....	S. E.	Steep.
Barnes "	S. E.	60°
Daniel Horton "	S. E.	50°

TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Combs mine.....	S. E.	45°
Chester, near Seward Hill.....	S. E.	.....
Cooper mine.....	S. E.	45°
Swayze ".....	S. E.	45°
Woodhull mine (upper stopes).....	S. E.	70°
" " lower part.....	S. E.	50°
Hardin farm openings.....	S. E.	Steep.
Hedges mine.....	S. E.	50°-65°
Peach Orchard mine.....	S. E.	Steep.
R. R. cut, ¼ mile northeast of Chester furnace.....	S. 45° E.	65°
Gulick, southeast openings.....	S. E.	60°
Hacklebarney mines, tunnel vein.....	S. E.	55°
" Coal House cut.....	S. E.	70°
" mines, northeast of river.....	S. E.	65°
Langdon's mine.....	S. E.	Moderate.
Hog Back ridge, northeast of Calfon.....	S. E.	Steep.
Solitude mine.....	S. E.	75°
R. R. cut, east of High Bridge.....	N. 75° E.	60°-70°
" " west of ".....	S. 60° E.	70°
Solitude mine.....	S. E.	75°
High Bridge mines.....	S. E.	65°
One mile southwest of Lebanon.....	Strike N. W.	.....
A. Sharp place, southwest of Lebanon.....	E. N. E.	.....
Large's mines, " ".....	Strike N. E.	.....
" " south of last station.....	Strike N. N. W.	.....
" " southeast of last station.....	Strike N. E.	.....

Musconetcong Belt.

Centennial, or Squiers mine.....	S. E.	80°
Ten Eyck mine.....	N. W.	Nearly vertical.
Near Pulis corner.....	S. 80° E.	80°
Green mine.....	S. E.	65°-72°
Wawayanda mine.....	S. E.	15°-50°
Clinton tract openings.....	S. 65° E.	85°

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TABLE OF DIPS—Continued.

Ramapo Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Brown place, near Pompton Plains.....	S. E.	70°
Kayhart mine.....	N. W.	65°
Vreeland "	S. E.	70°
Turkey Mountain limestone quarry..... {	N. E. N. 50° W.	Steep. Steep.
Near White Hall, corner of road to Turkey mountain.....	E. S. E.	80°-85°
North of Montville.....	S. E.	Steep.
Asylum quarry, Morris Plains.....	S. 45° E.	85°
Morris Plains, west border.....	N. W.	80°
Headley place, northeast of Morristown.....	N. W.	Steep.
Morristown, road to Brookside.....	E. S. E.	.....
Mendham, on Morristown road.....	S.	Steep.
Connet mine.....	S. W.	40°, nearly vertical.

Passaic Belt.

Ringwood, Hewitt mine.....	S. E.	89°
" New or Wood mine.....	S. E.	88°
" New Miller "	S. E.	60°
" Peters "	S. E.	40°
" Blue "	Strike N. E.	Vertical.
" Hard "	S. E.	60°
Board mine.....	S. E.	30°
Near D. Cisca's limestone quarry, West Milford township.....	E. S. E.	40°
East of Gould's quarry, near Macopin.....	E. S. E.	15°
Tellington mine.....	S. E.	40°
Y. Y., Susquehanna & Western R. R. cut, 1¼ miles west of } Smith mills.....	S. E.	Steep.
Hill, ¼ mile southeast of Charlotteburg.....	E. S. E.	60°
Quarry, southeast of Charlotteburg.....	E. S. E.	55°
Stony Brook mountain, Pequannock township.....	S. 50° E.	70°
West of Stony Brook church.....	N. W.	Steep.
Brown's shaft, west of Boonton and Bloomingdale road	S. E.	70°
Rockaway Valley mines.....	S. E.	50°-60°
Righter Mine.....	N. W.	Almost vertical.
Pike's Peak mine.....	S. 65° E.	60°

TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Taylor mine.....	Strike E. N. E.	.....
East slope of Lyonsville ridge.....	E. S. E.	Moderate.
At Lyonsville.....	S. E.	Steep.
West of Lyonsville, S. H.....	S. 30° E.	Moderate.
Splitrock Pond mine.....	S. E.	Very steep.
" or Cobb mine.....	S. E.	70°-78°
" furnaces, ledges in dam.....	W. N. W.	60°-70°
Beach Glen mine, northeast opening.....	N. W.	Very steep.
" " southwest " 	N. W.	Steep.
" " " " 	S. E.	Steep.
Hibernia (Willis) mine, surface.....	S. E.	81°
" " " 30 feet down.....	S. E.	78°
" (Upper Wood) mine.....	N. W.	Steep.
" " " " deepest stopes.....	S. E.	Nearly vertical.
" (Glendon).....	S. E.	86°
" brook, in adit tunnel.....	S. E.	60°
Beach mine, Hibernia.....	S. E.	80°
White Meadow mines.....	S. E.	75°
Mine holes, 1½ miles north of Rockaway.....	S. 60° E.	60°
Swedes mine.....	S. E.	50°
D., L. & W. R. R. cut, south of Rockaway.....	S. 45° E.	65°
Dover quarry, east of town.....	S. 42° E.	50°
" D., L. & W. R. R. Co.'s quarry.....	S. 45° E.	55°
" Central R. R. cut, (High Bridge Bra.).....	S. E.	55°
Charlotteburg iron mine.....	S. E.	.....
Kitchell tract, east of Copperas mountain.....	S. E.	38°-45°
West of Timber brook and near Copperas mountain.....	S. 45° E.	40°
Green Pond mines.....	S. 55° E.	35°-45°
" " southwest end.....	E. S. E.	30°
East of Davenport mine.....	E. S. E.	Nearly vertical.
East foot of Copperas mountain.....	E. S. E.	30°-45°
Near Green Pond brook, west of Denmark.....	S. 70° E.	Steep.
" " " " 	S. 65° E.	42°
Pruden's saw mill, south of Green Pond.....	S. 50° E.	70°
Hickory Hill deposits.....	S. E.	65°

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TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Mount Hope.....	S. E.	65°-70°
“ Teabo vein.....	S. E.	70°
“ Sturgis mine.....	S. E.	75°-85°
“ Elizabeth vein.....	S. E.	72°
Allen mine.....	S. E.	65°
Richards mine.....	S. E.	60°
Baker “	S. E.	80°
Dolan “	S. E.	45°
Mount Pleasant mine.....	S. E.	57°
R. R. cut, High Bridge Bra., Port Oram.....	S. 56°-60° E.	45°
King Hill, north end.....	S. 60° E.	55°
Johnson Hill mine.....	S. E.	40°
Randall Hill, northwest side.....	S. 35° E.	45°-50°
“ “ crest.....	S. 45° E.	30°
“ “ mine.....	S. E.	50°
Irondale, Hubbard mine.....	S. E.	30°-35°
“ Sterling “	S. E.	45°
“ Corwin “	S. E.	45°
Baker mine, on hill.....	S. E.	80°
King mine.....	S. E.	54°
Canfield mine.....	S. E.	50°
“ “ westernmost openings.....	S. E.	35°-40°
Canfield's phosphatic iron ore mines.....	S. E.	60°-70°
Dickerson mine (Big mine).....	S. E.	55°-60°
“ “ side vein.....	S. E.	Steep.
“ “ “ near surface.....	N. E.	Moderate.
Bryant mine.....	S. E.	60°
Byram “	S. E.	50°
North of Dalrymple mine.....	S. 35° E.	60°
Dalrymple mine.....	S. E.	Almost vertical.
DeHart “	S. E.	80°
David Horton mine.....	S. E.	80°
George or Logan mine.....	S. E.	Steep.
Barnes “	S. E.	60°
Daniel Horton “	S. E.	50°

TABLE OF DIPS—Continued.

Passaic Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Combs mine.....	S. E.	45°
Chester, near Seward Hill.....	S. E.	.....
Cooper mine.....	S. E.	45°
Swayze ".....	S. E.	45°
Woodhull mine (upper stopes).....	S. E.	70°
" " lower part.....	S. E.	50°
Hardin farm openings.....	S. E.	Steep.
Hedges mine.....	S. E.	50°-65°
Peach Orchard mine.....	S. E.	Steep.
R. R. cut, ¼ mile northeast of Chester furnace.....	S. 45° E.	65°
Gulick, southeast openings.....	S. E.	60°
Hacklebarney mines, tunnel vein.....	S. E.	55°
" Coal House cut.....	S. E.	70°
" mines, northeast of river.....	S. E.	65°
Langdon's mine.....	S. E.	Moderate.
Hog Back ridge, northeast of Calfon.....	S. E.	Steep.
Solitude mine.....	S. E.	75°
R. R. cut, east of High Bridge.....	N. 75° E.	60°-70°
" " west of ".....	S. 60° E.	70°
Solitude mine.....	S. E.	75°
High Bridge mines.....	S. E.	65°
One mile southwest of Lebanon.....	Strike N. W.	.....
A. Sharp place, southwest of Lebanon.....	E. N. E.	.....
Large's mines, " ".....	Strike N. E.	.....
" " south of last station.....	Strike N. N. W.	.....
" " southeast of last station.....	Strike N. E.	.....

Musconetcong Belt.

Centennial, or Squiers mine.....	S. E.	80°
Ten Eyck mine.....	N. W.	Nearly vertical.
Near Pulis corner.....	S. 80° E.	80°
Green mine.....	S. E.	65°-72°
Wawayanda mine.....	S. E.	15°-50°
Clinton tract openings.....	S. 65° E.	85°

TABLE OF DIPS—Continued.

Musconetcong Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Canisteota mines	S. E.	Steep.
Budd and Hunt tract.....	S. E.	65°
Williams' mine, northeast shaft.....	S. E.	Steep.
" " southwest "	N. W.	Steep.
Layton mine.....	E. S. E.	Steep.
South of Vernon—Snufftown road.....	S. 70° E.	70°
" summit of Snufftown road.....	S. 70° E.	Steep.
Franklin, Sykes' quarry.....	N. 50° W.	85°
N. Y., S. & W. R. R. cut, ¼ mile northeast of Ogdensburgh..	S. E.	60°-65°
" northeast of last station.	S. 55° E.	65°-70°
" still further to northeast.....	S. 60° E.	70°
" near Munson's gap	S. 60° E.	Steep.
" northeast of Munson's gap.....	E. S. E.	.....
" deep cut.....	Easterly.	Steep.
" ledges, 1 mile west of Snufftown....	E. S. E.	.....
" near Stockholm.....	N. 50° E.	60°
Stockholm, near Temple's.....	N. 70° W.	Moderate.
R. R. cut, near Stockholm and north of Dunker pond brook..	S. 65° E.	60°
" near saw-mill dam, Stockholm	E. S. E.	60°
" southeast of Stockholm.....	E. S. E.	60°
" Windham forge pond.....	E. S. E.	65°
West of Russia	S. E.	50°-80°
Northeast of Upper Longwood, 1¾ miles.....	N. 20° W.	80°
Longwood mountain.....	S. 50°-60° E.	80°, vertical.
Two miles west of Longwood valley.....	S. E.	50°-60°
Southwest of Lower Longwood.....	S. 55° E.	Nearly vertical.
Ogdensburgh road, west of Ogden mines.....	S. 70° E.	60°
Rock, near road, " "	S. E.	40°
Ogden mines.....	S. E.	Steep.
Sherman mine.....	S.	30°
Sickles' "	S. E.	.....
Gafney "	S. E.	50°
Northeast of Sickles' mine.....	E. N. E.	45°
Ford mine.....	S. 45° E.	80°
Weldon mine.....	S. E.	40°-45°
Lower Weldon mine.....	S. E.	50°

TABLE OF DIPS—Continued.

Musconetoong Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Near store at Woodport.....	S. E.	Steep.
Ogden mine R. R., near Hurd mine.....	N. W.	85°
Hurd mine.....	S. E.	85°
Near Lake Hopatcong.....	S. 45° E.	Steep.
Hopatcong station R. R. cuts.....	S. 45° E.	Nearly vertical.
Noland's mine, near Hopatcong Lake.....	S. E.	70°
Lake View mine.....	S. E.	Moderate.
Davenport mine, west of Berkshire valley.....	N. W.	50°
Ogden mine R. R. cut, west of Berkshire valley.....	N. 25° W.	70°
Sussex R. R., south of Cranberry reservoir.....	E.	20°-30°
White Rock cut, Sussex R. R.....	E. N. E.	20°
Herrick's, or Allen quarry, near Sussex R. R.....	N. 60° E.	40°
King and Forman lease.....	N. 65° E.	45°
Between Allis' and King and Forman tract.....	N. 65° E.	20°
Allis' mine.....	N. 65° E.	60°
Smith, or Cascade mine (old workings).....	S. 85° E.	60°
“ “ northwest holes.....	N. 80° E.	35°-45°
Andover and Stanhope road summit.....	E. N. E.	Steep.
Wright mine.....	S. E.	50°
Hude mine.....	E. N. E. S. E.	15°-30°
Burt mine.....	S. E.	Steep.
Drakeville.....	Strike N. E.	Vertical.
Mount Olive mines.....	S. E.	35°-45°
Hilt's mine.....	S. E.	75°
Osborn “.....	S. E.	45°
Drake's “.....	S. E.	45°
Stevens' “.....	S. E.	45°
Rarick farm, north of Naughtsville.....	S. E.	75°
Sharp diggings, “.....	S. E.	80°
Hopler place.....	S. S. E.	Steep.
Near Naught mine.....	S. 30° E.	Nearly vertical.
Stream, northwest of Naughtsville.....	S. E.	Steep.
Naught mine.....	E. N. E.	35°-40°
“ south drift.....	E. S. E.	40°
Brow of mountain, near Nack's mills.....	S. E.	Steep.

TABLE OF DIPS—Continued.

Musconetcong Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
Fritts' farm openings, N. E. Whitehall.....	E. S. E.	Steep.
C. R. R. cut, west of Willoughby run, east end.....	S. E.	60°
“ “ “ west end	S. E.	50°
“ 100 yards west of above locality	E. S. E.	70°
“ west end of above R. R. cut	E. S. E.	40°
“ ¼ mile east of Glen Gardner.....	S. 60° E.	50°
R. R. quarry, near Glen Gardner.....	S. E.	60°
Glen Gardner R. R. cut.....	E. S. E.	30°
R. R. cut, west of Glen Gardner.....	S. E.	60°
Cramer mine, east of Hackettstown.....	S. E. N. W.	Steep. Nearly vertical.
Robertson shaft, west slope, Schooley's mountain.....	E. S. E.	Steep.
Fisher, or Beattiestown mine.....	N. W.	Steep, vertical.
Stoutenburgh mine.....	S. E.	35°-40°
Hann farm	S. S. E.	30°
Pleasant Grove (Marsh & Trufant).....	E. S. E.	30°
“ (L. V. R. Co.'s pits).....	E. S. E.	Steep.
Pidcock mine.....	S. S. E.	50°-60°
D., L. & W. R. R. cut, east of Changewater.....	S. E.	Steep.
“ cuts, south of “	E. S. E.	Gentle.
“ 1st cut, west of Hampton Junction.....	E. S. E.	60°-80°
R. R. cut, east of and at Hampton Junction.....	S. E.	65°
“ “ “ “ west end.....	S. E.	35°
C. R. R. cut, ¼ mile northeast of Asbury.....	S. 60° E.	Steep.
Rodenbough mine, west slope.....	N. W.	Steep.
Asbury mine.....	S. 60° E.	60°
Church, or Van Syckle's mine.....	S.	70°
L. V. R. R. cut, Pattenburgh.....	S. E.	.....
Musconetcong tunnel, east end.....	N. N. E.	60°-70°
“ “ in middle.....	N. N. E.	Steep.
“ “ west end.....	N. 70° E.	40°
West end mines.....	S. E. S. E.	35° 45°-80°
Duckworth mine.....	S. 15°-20° E.	.....
R. R. cut, south of Riegelsville.....	S. 30° E.	38°

TABLE OF DIPS—Continued.

Musconetcong Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
R. R. cut, south of above locality.....	S. 25° E.	40°
Musconetcong Mt., southwest end, opp. Johnson's ferry.....	S. E.	45°
Near canal, west of Waterloo, Sussex county.....	N. E.	.....
Brookfield, or Waterloo mine.....	E.	33°
“ “ south drifts.....	S. 75° E.	Moderate.
Excelsior mine.....	S. E.	Steep.
Bryant mine, east of Warrenville.....	S. E.	Moderate.
Barton “ “ “.....	S. E.	Nearly vertical.
Young farm, north of Hackettstown.....	S. E.	Nearly vertical.
Trace “ “ “.....	S. E.	Nearly vertical.
Mitchell farm, Buck's Hill.....	S. E.	Steep.
Searle farm, west of Hackettstown.....	E. S. E.	Steep.
Smith, or Egbert Church mine.....	S. 75° E.	Steep.
Port Murray.....	N. N. E.	Steep.
Creager mine, Port Murray.....	Easterly.	.....
R. R. cut, east of Washington.....	S. 45° E.	50°
Smith farm, south end of Pohatcong range, north of } Bloomsbury..... }	S. E.	Moderate.
Pohatcong mountain, near Delaware river.....	S. 30° E.	Steep.
“ “ north slope, near Bel. Del. R. R.....	S. 45° E.	55°
“ “ south end of mountain.....	E. S. E.	.....
“ “ south slope and east of R. R..... {	S. 60° E. S. 80° E.	Moderate. 45°
“ “ at Delaware river.....	S. 75° E.	45°
Stewart's gap.....	S. 15° E.	Steep.
Van Nest Gap tunnel, east end.....	S. E.	75°
“ “ west end cut.....	S. 55° E.	65°
Mountain, southeast of Oxford furnace.....	N. 80° E.	70°
Southeast slope of mountain, near Chapin & Tommasson } tunnel..... }	N. 70° E.	Steep.
Chapin & Tommasson tunnel.....	N. N. E.	70°
Brasscastle road, ½ mile south of Oxford.....	N. 10° E.	50°
Oxford furnace, new mine.....	N.	55°-70°

TABLE OF DIPS—Continued.

Pequest Belt.

LOCALITY.	DIRECTION.	AMOUNT.
Owens' Island, drowned lands.....	S. 45° E.	70°
Crystalline limestone, near North Vernon.....	E. S. E.	Steep.
“ east of Hardystonville	S. 70° E.	.....
“ “ “	S. 60° E.	60°
Crystalline limestone ridge, near Hamburg mountain } and east of Mine Hill.....	E. S. E.	.....
Crystalline limestone, east side of Pochuck mountain.....	E. S. E.	.....
“ McAfee valley.....	S. 30° E.	65°
North Vernon	S. 30° E.	Steep.
Pochuck mountain, west slope.....	S. E.	55°
“ near Green's mine	S. E.	Steep.
Pochuck mine..... {	S. E. S. 30° E.	30° 50°
Tunnel to Pochuck mine.....	N. W.	Steep.
Pochuck mountain, southwest end Hamburg road.....	E. S. E.	Steep.
Franklin furnace, quarry.....	S. E.	55°
“ in Ogdensburgh road.....	S. E.	40°
“ furnace vein.....	S. E.	60°
“ front, zinc ore bed.....	S. E.	55°-65°
“ Buckwheatfield mine.....	Strike N. E.	Vertical.
Wildcat road, west of Franklin furnace.....	S. 70° E.	65°
East of Kimble's pond.....	S. E.	30°-35°
North end of Pimple Hills range.....	S. 35° E.	65°-70°
West of Pimple Hills.....	E. S. E.	50°
Stirling Hill zinc mine.....	S. E.	45°
House's corner.....	S. 80° E.	20°
One-half mile south of above locality.....	S. 55° E.	40°
East of Sussex lead mine.....	S. E.	12°
Pinkney's corner	S. 25° E.	40°
East of Strubble's, or Long pond.....	S. 20°-30° E.	60°-70°
Southeast shore of “	S. E.	40°
Adit to Tar Hill mine.....	W. N. W.	Steep.
Sulphur Hill “	S. S. E.	60°
Roseville mine { South openings.....	Strike N. N. E.	Steep to East and
“ North “	“ N. N. W.	Vertical.
Andover mine.....	S. E.	60°
Near white limestone, Andover.....	S. 70° E.	Moderate.

TABLE OF DIPS—Continued.

Pequest Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
O'Himenover's, Byram, white limestone.....	N. 70° E.	Steep.
Cranberry reservoir "	N. W.	.....
White Hall, or road to Stanhope.....	E. S. E.	80°
McKean, or Bird mine.....	S. E.	75°
Maring place, southwest of Warrenville.....	N. W.	Nearly vertical.
Hibler farm, or Livesey's shaft, Warrenville.....	S. E.	Steep.
Southwest of Barton mine.....	W. N. W.	.....
Howell farm, northeast Jenny Jump mountain.....	E. S. E.	70°
Near last locality.....	Easterly.	60°
Foot hills, northeast end of Jenny Jump mountain.....	Strike N. N. E.	Vertical.
East slope, north end of " "	N. 60° W.	Steep.
North end, or foot of " "	S. E.	Steep.
"High Rocks," Jenny Jump mountain.....	S. E.	50°
Jenny Jump mountain, north end.....	S. 75° E.	60°
Near Shaw mine, Jenny Jump mountain.....	N. 70° E.	45°
" " foot hills.....	N. 20° E.	20°-30°
" " " a second locality.....	N. 10° E.	25°
On Great Meadows, east of above.....	N. 25° W.	55°
Davis mine, on Jenny Jump mountain.....	S. E.	Steep.
Potter farm, east of Jenny Jump mountain.....	W. N. W.	Moderate.
Stinson mine, " "	S. 25° E.	60°
Inschow lot.....	N. W.	.....
Crystalline limestone, east of Jenny Jump mountain.....	S. 35° E.	75°
Northeast of Rose Crystal marble quarry.....	N. W.	Steep.
Rose Crystal marble quarry.....	N. 75° W.	80°
Hope and Danville road, mountain.....	Westerly.	Nearly vertical.
Kishpaugh mine	S. E.	28°-34°
" "	S. 55° E.	40°
Holt farm "	S. E. N. W.	25°-30° Gentle.
Henry tunnel	S. E.	Steep.
Pequest mine.....	S. 70° E.	60°-70°
Pequest rock cut, east end.....	S. 70° E.	65°-70°
" " west end.....	S. E.	65°

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TABLE OF DIPS—Continued.

Pequest Belt—Continued.

LOCALITY.	DIRECTION.	AMOUNT.
East of Buttzville, $\frac{3}{4}$ mile and north of Pequest river.....	S 25° E.	75°
" " east above station.....	S. 15°-40° E.	70°
Three-quarters of a mile south of Bridgeville, road to Oxford.	N. 45° W.	70°
Crystalline limestone, Oxford.....	S. 70° E.	Steep.
" "	N. 60° E.	Steep.
South of Oxford.....	N. 10° E.	70°
Raub mine.....	Strike E. N. E.	.....
Little mine..... {	S. E.	Steep.
	N. W.	Nearly vertical.
Redell "	S. E.	Steep.
Shoemaker mine.....	S. E.	Steep.
Barton mine, western shaft..... {	N. N. W.	60°
	N.	Nearly vertical.
Schuler "	S. E.	Steep.
Near Roxburgh.....	S. 50° E.	Steep.
Near Harmony.....	S. 40° E.	Steep.
Marble mountain, near Delaware river.....	N. 30° W.	65°
" marble quarry.....	N. 30° W.	55°
" north of "	N. 40° W.	50°
" near mine on top of mountain.....	N. N. W.	Moderate.
South point of ridge, north of Marble mountain.....	N. 20° W.	Nearly vertical.
North of last named locality.....	N. 40° W.	Gentle.

A study of the table discovers a few areas where the direction of the dip is not in accord with the general rule as stated above. There is a belt between Stanhope and the Cranberry Reservoir, traversed by the Sussex Railroad, where the prevailing dip is toward the east-northeast. The inclination varies from 20° to 60° in amount. At Oxford Furnace, the outcrops and the course of the ore, as opened in the mines, show a north-northeast direction. Other remarkable exceptions, but confined to much smaller areas, are at the Connet mine, Water street, Morris county, where the dip was said to be southwest; the Musconetcong tunnel of the Easton and Amboy Railroad, where northeasterly dips were observed; Large's openings, south of Lebanon, in Hunterdon county, and the foot hills at north end of Jenny Jump mountain. The northwest dips or direction may be considered as overturned or reversed from the southeast, as there is no change in the strike in that case. And, as a rule, the dips in that quadrant are steeper than those to the southeast. The southeast, the vertical and the northwest dips can all be referred to the same uplifting and tilting force, varying in intensity from the normal southeast to the overturned and northwest dipping strata. The consideration of these variations in direction or exceptions is noticed in the head of the strike.

A comparison of the amount of the dip leads to the following generalization: 1. The average dip in the Ramapo belt is 65° ; in the Passaic belt, 58° ; in the Musconetcong belt, 55° , and in the Pequest belt, 54° . The diminishing steepness of the inclination, going northwest, is noteworthy. Looking at the localities in the several belts, the dips on the eastern side of the Passaic belt are steep, from 50° to 80° ; while on the west border of the same belt and near the newer rock outcrops of West Milford township and of Kanouse, Copperas and Green Pond mountain ranges, the strata dip at moderate angles, from 30° to 45° to the southeast. In the Musconetcong belt and in the northern part of it, the strata stand highly inclined to the east-southeast, from 60° to 85° , and with some reversed or northwest dips. On the Schooley's mountain range of this belt, there is quite wide range in the angle, and, although there are steep dips on its southeast border and more gentle ones to the west, the exceptions are sufficient to render any generalization premature and uncertain. On the mountain range west of Hackettstown and northeast of Washington and Oxford Furnace, in Warren county, the average dip is not so steep, but is almost uniformly toward the southeast quarter.

The Musconetcong and Pohatcong mountain ranges show gentler dips, from 40° to 55° and to southeast. The Pequest belt offers more variation. And there is a remarkable section along the Delaware, in Marble mountain, where the beds all incline at angles of 30° to 40° toward the northwest. On the northwest border or slope of the broad Scott's mountain, and also on Jenny Jump mountain, the strata are more highly inclined and toward the southeast. An area of comparatively gently dipping strata in this belt is found between Franklin Furnace and Andover, in Sussex county. The average angle of dip on this border of the Archaean rocks is between 20° and 40° , uniformly to the southeast.

In the above-mentioned table there are many observations from the iron mines. As a rule, the dip at greater depths in them is found to vary much according as the points of observation are taken where the walls pinch or where they swell out, enclosing large shoots of ore. Taking the mean descent, or *underlay* (of the miners), there is less variation in the mines than in the rock outcrops on the surface. Again, experience and observation of practical men shows that this descent or dip is generally less at increasing depths. And vertical or even northwest dips, as at Hibernia in the Upper Wood mine, for example, are found to change to southeast. The vein is said "to right itself," *i. e.*, to assume its natural or normal dip. Sometimes the dip is observed to change several times in descending, as in the Side Hill vein at Mount Hope. But as a rule the northwest dips at the outcrops are found to change in following the ore down.

STRIKE.—The *strike* may be defined as "the intersection of the inclined bed with a horizontal plane." It is at right angles to the line or direction of the dip. It is often spoken of as the course or range of the rock or ore. From what has been stated above describing the dip, it follows that in our Archaean rocks the prevailing direction or *strike* is northeast and southwest, varying, however, in many cases from north around to east. Many observations upon the strike are given in the table of dips (pp. 39–50). The exceptions to this general course or direction also have been referred to on page 51. An examination of the dips and of the observations on the strike shows a gradual *easting* in going across the State from the New York line to the Delaware. And at the southwest the strike is more to the east-northeast, whereas in the northern part of

our Highlands it is nearly due northeast. This feature, as it was expressed in the structure of the country, was represented by a diagram in the *Geology of New Jersey*, 1868, p. 51. The trend of some of the ridges and valleys and mountain borders, as measured on the large topographical maps of the Survey, are here inserted.*

1. Southeast border of the Ramapo mountain and border of the gneissic rock outcrop..... N. 38° E.
2. Southeast border of the gneissic rocks from Morristown southwest..... N. 38° E.
3. Rockaway valley..... N. 35° E.
4. Valley of the Rockaway and of Hibernia brook..... N. 36° E.
5. Ramapo mountain, central or medial line..... N. 38° E.
6. Ramapo mountain, northwest line of summits..... N. 30° E.
7. West Milford valley and Greenwood lake..... N. 31° E.
8. Longwood valley and Succasunna plains..... N. 39° E.
9. Eastern border of gneiss outcrop, west of Bearfort Mt..... N. 28° E.
10. West border of gneiss, Pinkneyville to Andover, Sussex Co... N. 40° E.
11. Range of crests from New York line to Macopin, West Milford..... N. 26° E.
12. Range of crests east of German valley, Morris Co..... N. 39° E.
13. Schooley's mountain range, medial line..... N. 45° E.
14. Musconetcong valley, along southeast border, Hackettstown to Hampton..... N. 43° E.
15. Musconetcong mountain, southwest, near Delaware river.... N. 55° E.
16. Mountain west of Musconetcong valley, south to Washington..... N. 46° E.
17. Pohatcong mountain..... N. 50° E.
18. Pohatcong valley..... N. 48° E.
19. Mountain west of Pohatcong valley, east border... N. 52° E.
20. Frome's hill and Scott's mountain crests..... N. 46° E.
21. Northwest crest line of Jenny Jump..... N. 50° E.
22. West border, or foot of Jenny Jump..... N. 47° E.
23. West border of foot of Scott's mountain..... N. 46° E.
24. Marble mountain..... N. 51° E.

The lines of strike do not, however, always coincide with these crest lines or the trend of the valleys. The topographical maps show

* Bearings referred to true meridian.

ridges and valleys which are marked exceptions to the general rule, and run obliquely to the trend of the formation. Thus, the Wynokkie Valley trends north 13° east. Northwest of Bloomingdale and north of the Pequannock, the northerly trend of the ridges is a conspicuous feature of the surface. On Pochuck mountain also, there are north and south crests which stand oblique to the general course of the mountain mass. Others less prominent may be seen by referring to the maps.

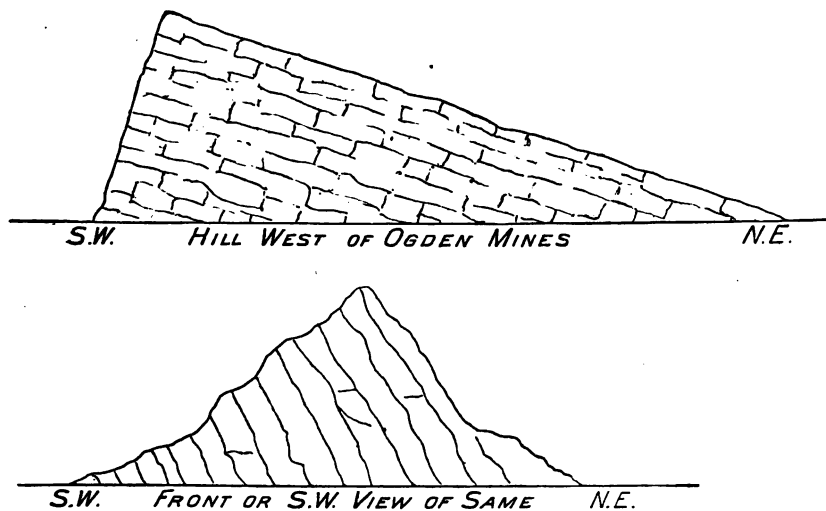
PITCH.—The beds of iron ore, or *veins* as they are generally termed, in our mining districts, when followed a considerable distance on their outcrops, or horizontally, are found to wedge out and the mass descends. This descent of the bodies of ore has given rise to the term "pitch." And the angle which the *vein* or *shoot* of ore makes with the horizon, in the direction of the strike, is the amount of the pitch. It is, as it were, the dip or descent of the bed in the line of strike; and the definition of "an inclined or dipping strike" has been given, though not strictly correct. This phenomenon is not observed in the ore only, as the rocky beds show it also, but owing to the greater excavations in mining as compared with the openings in rock alone, it is more easily observed in the former. And it is still more prominent when the ore occurs in the lens-shaped bodies termed "shoots." If there are several of them following one another, each shows the same pitch. Where the strike is northeast, the pitch must be either to the northeast or southwest. As a law of occurrence, the northeast pitch prevails. It is so common that in practice the miner works his *vein* on this assumption, excepting in the few localities where the strike is north or north-northwest. The mines in these latter areas are yet too few to give any general law. A few southwest pitches are to be seen on consulting the table here inserted. In it the locality is given first, then the direction, and last the amount or angle of descent.

TABLE OF PITCH.

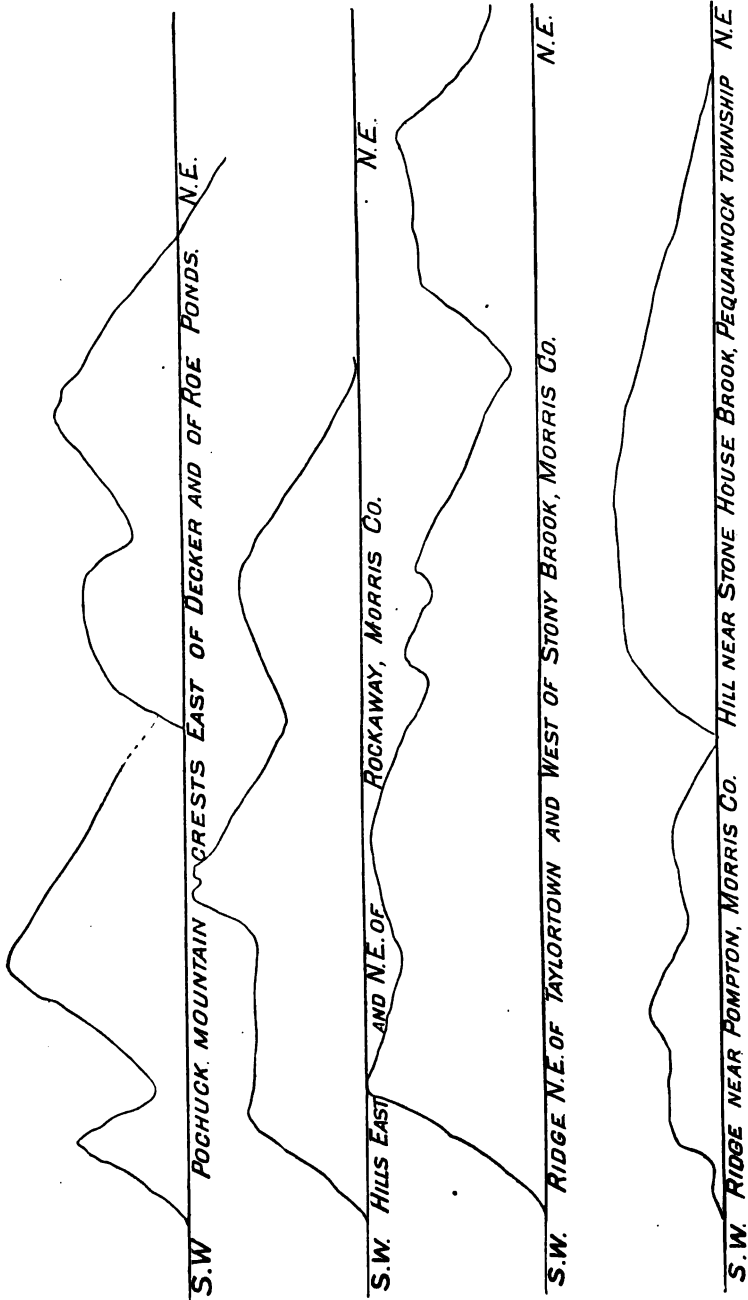
LOCALITY.	DIRECTION.	AMOUNT.
Hope mines, Ringwood.....	N. E.	55°
Cannon mine, ".....	N. E.	45°
Old Blue " ".....	N. E.	60°
Mule " ".....	N. E.	45°
Keeler " ".....	N. E.	40°
Bush " ".....	N. E.	80°
Wynokle " Wynokle.....	N. E.	58°
Rockaway Valley mine, Rockaway Valley.....	N. E.	Steep.
Taylor Vein, Mount Hope.....	N. E.	25°
Richard mine.....	N. E.	.....
Sweed's ".....	N. E.	15°
Green Pond mines.....	N. 38° E.	80°
Stirling mine, Irondale.....	N. E.	18°
Dickerson ".....	N. E.	45°
Bryant ".....	N. E.	25°
King ".....	N. E.	50°
George or Logan mine.....	N. E.	45°
Lawrence mine.....	S. W.	.....
Connet ".....	S. E.	.....
Sampson " Chester.....	N. E.	22°
Hedges " ".....	N. E.	60°
Hacklebarney mines.....	N. E.	40°
Lower Weldon mine.....	N. E.	20°-33°
Weldon mine.....	N. E.	26°-37°
Ford and Schofield mines.....	N. E.	25°-40°
Hurd mine.....	N. E.	22°-25°
Gove ".....	N. E.	20°-40°
Naughtright mine.....	N. E.	80°
Langdon ".....	S. W.	20°
High Bridge ".....	N. E.	60°
Furnace mine, Franklin.....	N. E.	.....
Sulphur Hill mine, Andover.....	N. E.	80°
Kishpaugh ".....	S. W.	15°
Pequest mine, near Oxford.....	N. E.	70°
Stirling Hill (zinc) mine.....	N. E.	62°
Forest of Dean mine, New York.....	N. E.	27°-28°
Hogencamp mine, Greenwood, New York.....	N. E.	20°

The observations upon the pitch of ore masses and rock strata are insufficient to give any laws or order in their arrangement, or to lead to any conclusions of practical value, other than what has been already stated.

This phenomenon of *pitch* is noticeable in the structure of the Highlands at many localities. The many outcrops of rock whose southwest fronts or slopes are steep and bold, and northeast slopes gently inclined, are examples of pitch. And a close examination will prove that these peculiar features of the surface are not due to glacial wear, as might at first be supposed, but are structural. North of the terminal moraine line, where the surface earth and debris of disintegrated rock outcrops have been removed, they can be seen to better advantage, and examples are more numerous than to the southwest. The following views of one of these hills is given to illustrate this statement. It represents the two slopes of a ridge near the Ogdensburgh road, west of the Ogden mines, in Sussex county. The hill is quite a conspicuous object in the landscape, and is nearly destitute of shrubbery and vegetation. It may be taken as typical of many outcrops. To show how this structure is to be seen in the longer ridges



and hills, sections have been constructed from the contour lines of the topographical maps. They are distorted by the inequality of the scales for the horizontal and vertical representations, but the northeast



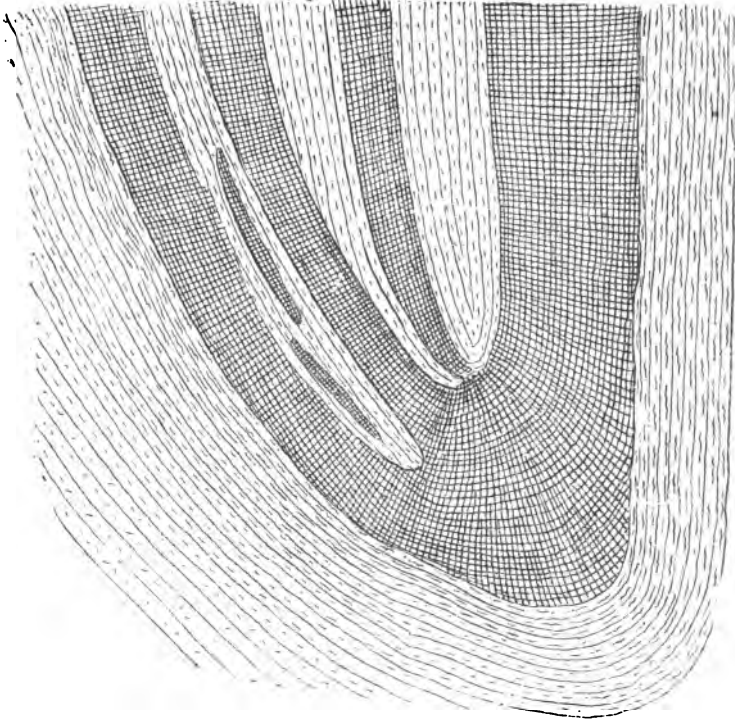
PROFILES OF HILLS, SHOWING PITCH TO NORTHEAST.

Scale—Horizontal, 1 in.=2,640 ft.; vertical, 1 in.=320 ft.

and southwest slopes are relatively correct. And the marked difference between them is at once evident in each one. It would be easy to increase largely the number of these hills and ridges, but persons who are familiar with our Highlands are well acquainted with this feature of the surface. On account of denudation by streams and the action of glaciers and the surface drainage through long ages, the more prominent hills have been worn down, and no doubt in many cases obliterated. In places the reverse may be true and some of the southwest points may have become more prominent than they were originally. From the topographical maps of the southwestern portions of the Highlands, it is evident that the northeast slopes are relatively steeper than those toward the southwest, the reverse of what is characteristic of the country to the northeast. So far as the testimony of the mines go, this position is confirmed by them. But in all the country south of the terminal moraine, the disintegrating effects of the atmospheric agencies have been carried to so great depths that the rock structure is concealed, and there are no such extensive rock outcrops for study as to the northeast.

The elements of *dip* and *strike* are essential features of stratification as ordinarily observed. Horizontal strata of any extent are scarcely seen in our Atlantic Coast region. And the most recent beds have a dip when tested by lines of level crossing them. There are elements in stratification, or phenomena of structure observable in stratified rocks which may be termed accidental, as distinguished from the essential phenomena of dip and strike. Among the accidental elements may be noted folds, faults, shoots and pinches.

FOLDS.—The force which raised the original gently-sloping or horizontal strata into inclined positions also compressed them together into more or less close folds. Wherever the arch of the fold is above, or at the surface, and the strata descend each way from a central line or axis, there is an anticlinal fold. Conversely, where strata dip from two sides towards a central line, forming, as it were, a trough-like depression, the fold is said to be a synclinal one. The former is represented by the inverted V or U; the latter is V-shaped or U-shaped, as the case may be. Folds of each kind are common in the newer rocks, and they have been finely exhibited in the anthracite coal basins. And their existence in the Archæan rocks of our Highlands is known by good examples of synclinal folds. One of the best of them is that



Synclinal Folds at Hurd Mine.

of the Hurd mine ore bed, at the old southwest opening, near the turn-pike. The above plate represents by its cross-barred lining the shape of the ore at this locality. The folded ore body pitches to the northeast and hence this southwest outcrop, as here figured, represents the end of a synclinal, whose axis descends to the northeast. The long slope, now over 2,000 feet, is following the line of the axis, and the ore appears to be a close fold and without any interbedded rock between its two legs or sides. Another synclinal fold is to be seen in the zinc mines on Mine Hill, Franklin. The front and back veins of ore terminate at the southwest in what is known as the southwest opening, and appear to be parts of a great and deep fold. [See *Geology of New Jersey*, pp. 334 and 672.] The veins at Stirling Hill, in the mines of the Passaic Zinc Company and of the Franklinite Iron Company, are also connected at the southwest and parts of what appears to be a synclinal fold. The exposures of rock away from mines are

not so extensive as to show unmistakable examples of folds, though long cross sections exposing many consecutive beds are seen in railroad cuttings and along some of the larger stream valleys which traverse the Highlands in northwest and southeast courses. It is difficult to prove the repetition of strata in them indicating folds. And there are no localities of plainly marked opposite dips also suggesting folding as their cause. At the Green Pond Mines and at the Hoit Farm Mine the bottom rocks, as they were exposed several years ago by the removal of the overlying ore beds, formed saddles or anticlinals, but the surfaces thus exposed were too small to consider them of much importance in a general study of the structure. They may have been horses of rock whose upper surface had been bared of the ore.

In the second cut west of High Bridge on the Central Railroad the beds appear to be repeated on each side of a central or medial line and they, probably, represent a fold. The locality was figured in the *Geology of New Jersey*, 1868, p. 59. It is uncertain whether it is an anticlinal or a synclinal. In the Highlands of the Hudson at Iona Island Station, the H. R. R. cut exposes strata which dip around toward an axial line, as it were, the southwest end of a synclinal fold. On the west side of the Hudson the northwestern ridge of the Highlands is apparently a huge, closely-folded synclinal, as can be seen by the steeply dipping strata on each side of it. The best section is that crossing it on the new West Point and Canterbury road. The variation in the average dips of the strata on the southeast and on the northwest sides of our mountain ranges has been pointed out as a proof of their synclinal structure. Thus in the Schooley's mountain range the dips on the southeast border appear to be rather steeper than those on the northwest side. The steeper slopes toward the southeast in the case of nearly all of the Highland ranges is probably caused by the strata on that side being more highly inclined than on the northwest slopes. This difference in inclination indicates folds whose axes are not vertical, but inclined slightly from the vertical and dipping toward the northwest steeply. The more plausible theory regarding them is that the ridges or mountain ranges are anticlinals with the synclinal valleys separating them, or lying between them. The present surface is not the summit of the original arch, but a section across it made by the long continued wear of atmospheric agency.

In this place it is to be remarked that there is a great degree of uniformity in the altitudes of the mountain ranges of the High-

lands. A large area south of Dover and Rockaway and west of Morristown has an average elevation of 800-900 feet.* And the traveler attaining the summit of this plateau, as it were, recognizes the general level as characteristic of it. The broad Schooley's mountain range, extending southwest to where the Central railroad crosses it, is another example of this uniformity in height, having an average elevation from 1,000 to 1,200 feet. Scott's mountain has about the same average height. Another remarkable table land is in the northeastern part of Sussex and the western part of Passaic counties. Its mean height is probably over 1,200 feet, as there are many summits over 1,400 feet, and scarcely any depressions less than 1,000 feet. The surface is by no means level or even an approximation to a plane; but there are no very prominent peaks or ridges, nor any deep hollows or valleys. This uniform feature of the surface is not accidental, but must have had its origin in some way related to the original uplifting and folding of the strata, modified greatly by the subsequent erosion due to drainage and to glacial action in part. The tops of the folds have been planed off and worn down, but not so as to obliterate what seems to have been a feature of the old surface. That each ridge or mountain is made up of a single anticlinal fold is not probably true in every case. It is more reasonable to suppose that there are series of folds side by side in the broader table lands whose bases are far down in the earth, and their original upper surfaces removed long since by the wear of time. The newer rocks of the included valleys of the Highlands show both anticlinal and synclinal folds, though there is a general synclinal structure, as, for example, in the long belt of blue, magnesian limestone in the Musconetcong valley, which corresponds to the enclosing troughs or basins of the older crystalline rocks. And the apparent conformity in dip in the older and in the newer strata is evidence of the synclinal structure of these valleys. There are, however, so many places where the near outcrops of these two series of rocks are unconformable that this conclusion is not without much doubt. From the fact that the strata would be most easily and readily abraded where they were most subjected to strain and breaking, as at the summit of anticlinals, or at the top of the arches, it is fair to assume that the valleys

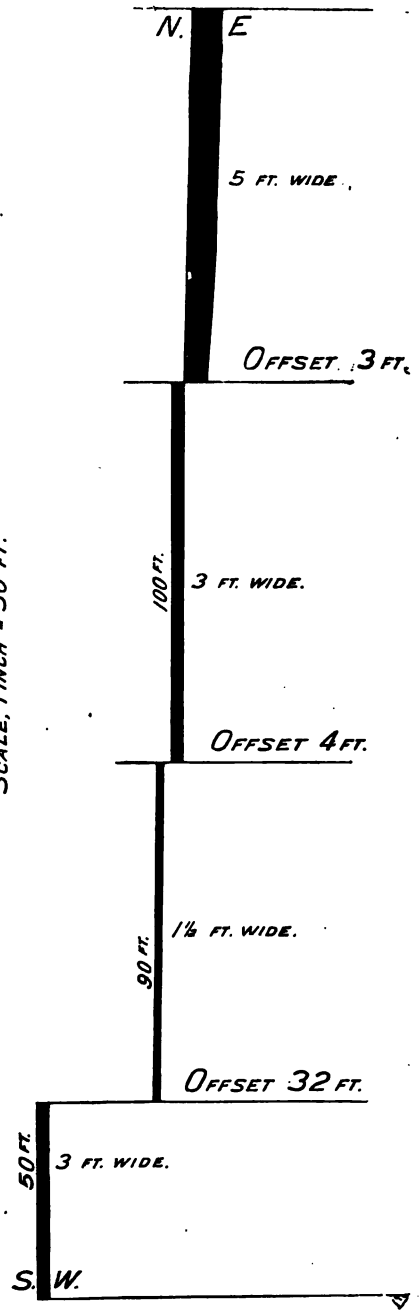
* The following heights are taken from a single narrow ridge, twelve miles long from Califon northeast, and east of German Valley: 862, 944, 944, 960, 987, 977, 914, 907, 960, 987, 977, 914, 907, 965, 989, 940, 862, 944, 864, 892, 946, 966 and 953—giving an average for the crest of 937 feet.

or depressions would have their beginning near or on the lines of these anticlinals, and that the elevations or mountains would, therefore, consist of synclinal folds. In the present state of our knowledge of all the facts of structure, it is impossible to indicate the lines or axes of folding, and prove what were its turns, up or down, anticlinal or synclinal. Probably both forms will be found entering into the structure of both mountain and valley, and in greater frequency than is at present supposed. It has been suggested that some of the ore ranges are parts of great folds, and that the bottom of the same would be found in deep boring or shafting in the intermediate ground. But there is no proof, in the nature of the ore or of adjacent rocks, so far as at present known, of any such examples of folding. Our deepest mines give no indications of the veins turning to the surface again. It is only the more superficial foldings which can be looked for in the iron ore beds; and they are seen in the Hurd mine and at other localities.

FAULTS.—The strata have not only been tilted and bent together into close folds, but they have also been torn apart, and the once continuous beds have slipped past one another, so that there is no longer an exact correspondence between the two sides of the rent or fault. Various other names are given to such displacements, and they are known as *offsets*, *heaves*, *slips* and *slides*. They may be referred to two principal classes: First, those in which the plane of displacement runs in the line of the strike of the strata; and, second, where the course of the fault traverses or cuts the strata more nearly in the line of the dip. In the first class the displacement is longitudinal or lengthwise; in the second it is crosswise. But there are gradations from one to the other, as faults occur cutting the strata at all angles. The amount of the displacement or offset is sometimes known as the *throw*; and it is an *upthrow* or a *downtthrow*, according as the strata are displaced up or down. The term *hade* also is used to designate the angle which the plane of the fault makes with the vertical plane. As a rule, the throw is toward the down side, or the upthrow overlies the hade. The same principle guides in the case of lateral displacements where the vertical plane of a fault cuts the strata obliquely. The search should follow the larger angle. Where the displacement is in a contrary direction, it is said to be a reversed fault. In the iron mines, a rule is that the throw is righthanded—that is, for

PLAN of FAULTS, - OF OFFSETS
Randall Hill Mine,
MINE HILL, MORRIS CO.

SCALE, 1 INCH = 50 FT.

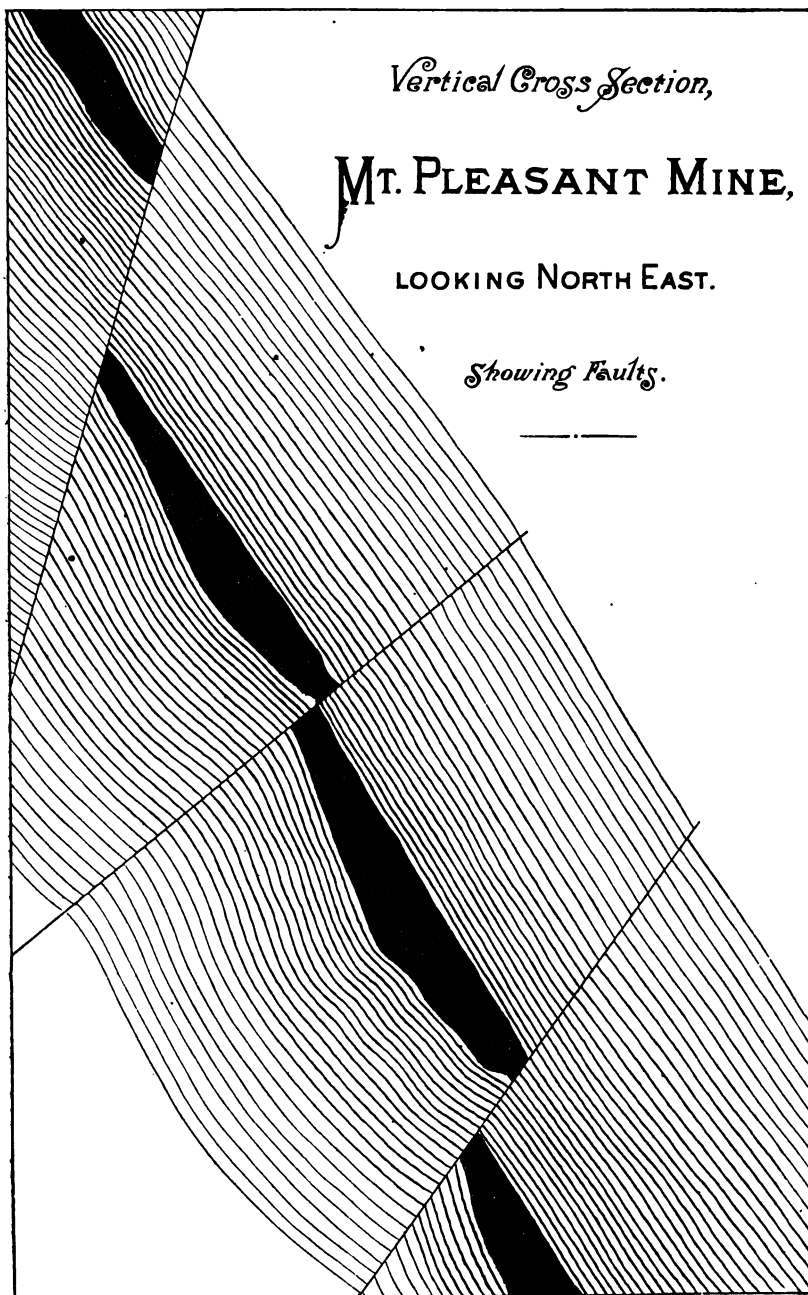


example, into the hanging wall or southeast, when following the ore in a northeast course and on the strike of the bed. Faults of this kind are common, and are recognized and regarded almost as characteristic features of the ore. The amount of displacement varies greatly. At the south end of Hickory Hill and north of Mount Hope it is fully 100 feet. No doubt there are greater offsets to be found. And some of the ore ranges look as if, originally, they were parts of one continuous line or range offsetted many hundreds of feet. Thus, the Hibernia range has been thought to be the northeast extension of the Mount Hope mines, though there are serious objections to such a theory. The apparent want of resemblance between the gneissic ranges on the two sides of the Delaware river suggests faulting on a large scale as a possible explanation. As an illustration of faults or offsets in a bed of iron ore, the map or plan of the Randall Hill vein is given on page 63. In this case there are three offsets, each *right-handed*, into the hanging wall to southeast. The amount of throw is given on the figure.

In some mines, as in the western part of the Mount Pleasant, and in the old Byram mines, the offsets are not all in the same direction. When faulted in this way, the course is made very irregular, and the work of mining made difficult. A very plain and well exposed fault can be seen in the Hacklebarney mines, northeast of Black river. Here the course of the fault is at right angles to the ore bed, and its plane is vertical. The throw is 30 feet into the hanging wall side. Other good examples of offsets are to be found in the Cooper mine at Chester, at Irondale, at the Pardee Ogden, at Hibernia in the Lower Wood mine, besides many others. [See descriptions of mines in Report.] The map of the Irondale vein shows the size of the fault in the Corwin mine at the southwest, and the so-called North River offset which separates the Harvey from the North River mine.

Of the second class of faults the Mount Pleasant mine affords a very good example. It is shown in the figure on the opposite page.

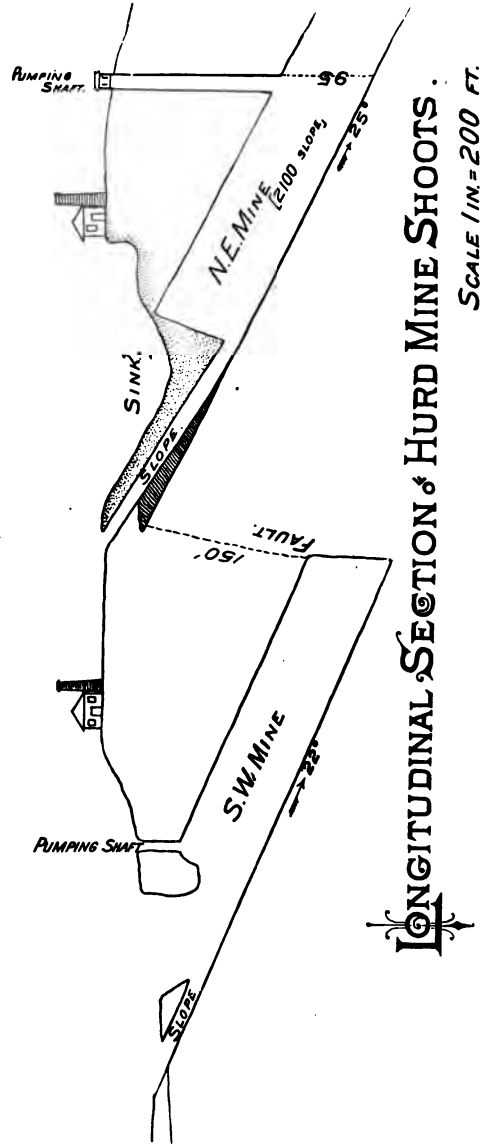
The *throws* here are termed *cross slides*. The general course of the faulting lines corresponds with that of the ore, but the planes of the faults dip at various angles toward the northwest. In the upper one the bed is thrown down 40 feet; in the next, 5 feet; in the third, 14 feet. In each case the throw is into the foot-wall side. And the planes follow the *pitch* of the ore shoots down to the northeast, and really separate them from one another. It would seem as if the strain



or tension along the pinch lines had been so great as to sever the ore and rocks. *Cross slides* and slips of the same kind, but not so marked nor with so much throw, are quite common in the iron mines. Another example of vertical displacement is at Hurdtown. The figure on opposite page is a reduced copy of a longitudinal section of the Hurd mine constructed from surveys made a few years ago. The shoot opened at the southwest and near the road, was followed down to the end of the ore, as indicated in the section. The northeast extension of the same shoot was found higher up, beyond this fault, and the amount of the dislocation is about 150 feet. One or the other of these parts must have been thrown down as the other was raised up.

The amount of displacement in many cases is very small, not equaling the breadth of the ore, so that the walls are but slightly irregular. They do not increase materially the difficulties in mining. It should be added that so far as the experience of our iron mines teaches, the most common faults are those where the plane of faulting is approximately vertical and at right angles to the strike.

PINCHES (AND SHOOTS).—These terms are confined to the ore bodies almost exclusively. They designate so common features in the ore that it is scarcely proper to call them accidental elements of stratification. And yet, considering the ore as a member of a stratified series, they are not essential to stratification. From what has been said under the head of *pitch* in the shoots of ore, the nature of these peculiar ore bodies has been indicated already. The term *shoot* is applied to the somewhat irregular, lens-shaped or lenticular bodies of ore which lie conformably between strata of rock, and which possess, in common with the country rock, the elements of pitch and dip, and are subject to faulting in all directions. They lie with their longer axes in the line of the *pitch*, or, in other words, the pitch is the angle at which they descend in the rock. Their dimensions vary indefinitely. Even the same shoot may vary from point to point and its successive cross sections show much irregularity. Besides the walls which bound it on the dip slopes, there is the *cap rock* which limits it at the top, and the *bottom rock* which underlies it. Generally the walls are seen to approach quite together, making an arched roof or *cap* and a trough-shaped floor or *bottom*, and the vertical cross section is of elliprodal shape. The accompanying sections of the Hurd mine



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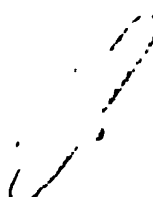
HUNT MINE

THE HUNT MINE

THE HUNT MINE

THE HUNT MINE

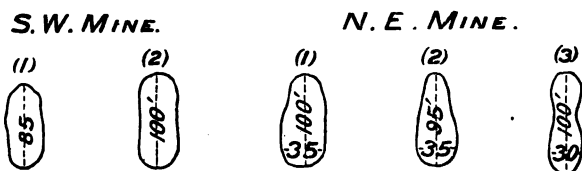
THE HUNT MINE



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The above plate shows a horizontal section of the mine, which has been worked at the southwest and at the northeast. The section shows vertical cross sections of the mine, which are shown in feet. The distance from the bottom of the mine to the height; that from the foot wall to the top of the mine. In some cases these dimensions are given in feet, in others the breadth exceeds the length. The length also is exceeding the breadth. The mine have been completely worked to great depths and their average size may be 30 to 40 feet in length. The mine are separated from the surface and connected with the surface by a series of shafts and adits.

other by thin sheets or *strings* of ore, which are termed *pinches* vein. Hence, these terms often express features in one and the same vein. The vein where it thins out or wedges out, apparently changed into a thin sheet or plate, is said to be *pinched*. And in the vein there may be an indefinite succession of these shoots, sepa-



VERTICAL CROSS SECTIONS
OF HURD MINE.

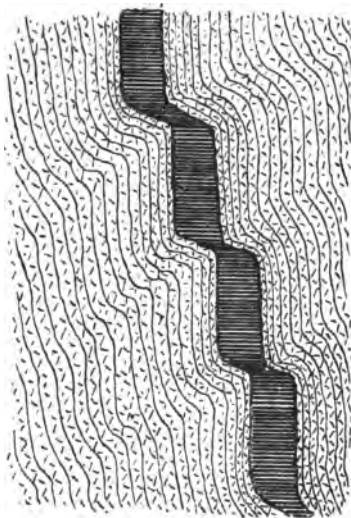
SCALE 1 IN. = 200 FT.

ated from one another by the so-called *pinches*. They may follow one another longitudinally, endwise, or they may lie side by side in the same general plane and each having the same pitch. The *pinches* may, therefore, separate the shoots both lengthwise and *sidewise*, i. e., in the line of the pitch and in the line of the dip also. Recognizing these features peculiar to the shape of the ore masses, there is what is termed the *shoot and pinch structure*.

The *pinches* in the ore are caused in some cases by irregularities in both walls. And they converge or approach one another by irregular rolls and the ore is squeezed into the thinnest recognizable layer or sheet. A peculiar form of *pinching* is caused in some cases by a flattening of the walls, but not so as to produce a parallelism, and the result is a narrowing of the *vein* into pinches. The diagram on page 70 illustrates this feature of structure. Examples of it are to be seen in the Kean mine near Chester, and at Mount Hope, besides other localities. Rarely are the walls found coming together so as to pinch out the ore completely. As it is not profitable work to follow so thin leads and pinched-up veins, miners and practical men speak of the ore as pinched or cut out even in such cases. But it is more often the fact that the pinch is caused by rolls in the foot wall, the hanging wall retaining its regular dip and strike. The foot wall is seen to grow flatter and approach the opposite wall, by a series of step-like *offsets* which are sometimes called *rolls* and sometimes *slides of rock*.

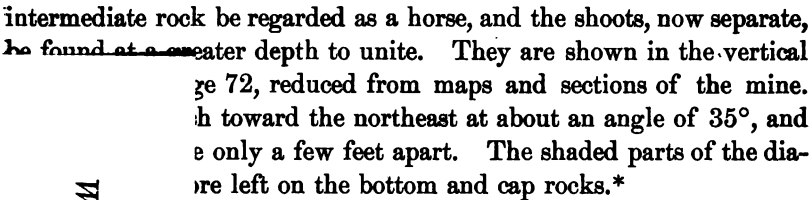
When both walls have rolls of this nature and are not strictly parallel, a succession of shoots and pinches are produced. Following the ore lengthwise the shoot-like irregularities in the walls are observed to produce pinches between the end of one shoot and the beginning of another. The walls here may approach each other at uniform angles, or, what is generally true, a succession of slabs of rock come in on the foot wall and leave no room for the ore shoot, and a pinch results.

*Vertical Cross-Section
of a magnetic iron ore bed*



The extent to which the ore may be *pinched* is well illustrated in the Richard mine, where a horizontal drift for 300 feet followed a vein of ore whose average thickness was not over a foot. The drift in this instance reached a second and large shoot of ore. Examples of drifting through pinches for hundreds of feet, in unsuccessful searches for other shoots, are well known in the costly experience of some of our mining superintendents. In the practice, these narrow parts of the vein are left as pillars, and in our large mines the plan of working is arranged with a view to a removal of the shoots of ore with as little work in the pinches as possible.

Shoots of ore nearly parallel and side by side, have been opened in the Weldon mine. This mode of occurrence is exceptional, unless the

intermediate rock be regarded as a horse, and the shoots, now separate, ~~be found at a greater depth to unite.~~ They are shown in the vertical  ge 72, reduced from maps and sections of the mine. It is toward the northeast at about an angle of 35°, and the layers are only a few feet apart. The shaded parts of the diagram are left on the bottom and cap rocks.*

Of the various phenomena of the structure of these rocks, as dip, strike, pitch, folds, faults and pinches, might be the angle of discussion. When it is remembered that this is the oldest known stratified rocks, and that they are subjected to the action of repeated uplifting and compression, to the wear of ages of exposure to the atmospheric element, to the subsequent denudation and abrasion of the surface, the complicated structure is not surprising, but an almost inevitable result. To retrace the steps in this long history is not possible, in view of the scanty data in our possession. The original deposition and the causes of the various structure, are all that can be indicated at present.

They are found in beds of varying thickness and extent, and, in another irregularly, as newer strata or even as very recent are seen to consist of alternating series of thick and thin. In their composition also it seems highly probable that they were formed under conditions somewhat similar to those which obtain in the deposition of beds of sand, clay, marl and iron ores in recent times. They must have been sandy, clayey, calcareous and ferrous like these modern deposits in some respects. Uniformity of structure have prevailed over larger areas than they do to-day, the extensive outcrops of rocks having the same general character and composition. The lakes, marshes or basins in which the deposits of iron oxides or iron carbonates accumulated were ~~very extensive~~, and apparently of equally great breadth, and the deposition was long continued, forming thick beds, when they in turn were covered by other sediments. Thus the accumulation went on as the older strata gradually and slowly subsided until the thickness amounted to thousands of feet. The time was long, perhaps as great in length as the combined ages of all the later formations. With the subsidence of the beds, the agents, pressure, heat and water, came into action, producing the great changes wherein these fragmental sedi-

* The horizontal lines in the figure have no structural significance.

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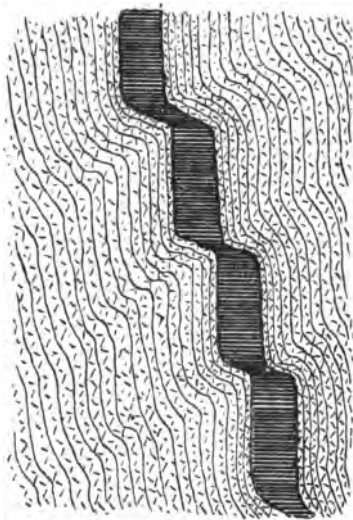
With the Compliments of

GEO. H. COOK,

STATE GEOLOGIST.

When both walls have rolls of this nature and are not strictly parallel, a succession of shoots and pinches are produced. Following the ore lengthwise the shoot-like irregularities in the walls are observed to produce pinches between the end of one shoot and the beginning of another. The walls here may approach each other at uniform angles, or, what is generally true, a succession of slabs of rock come in on the foot wall and leave no room for the ore shoot, and a pinch results.

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of a magnetic iron ore bed*



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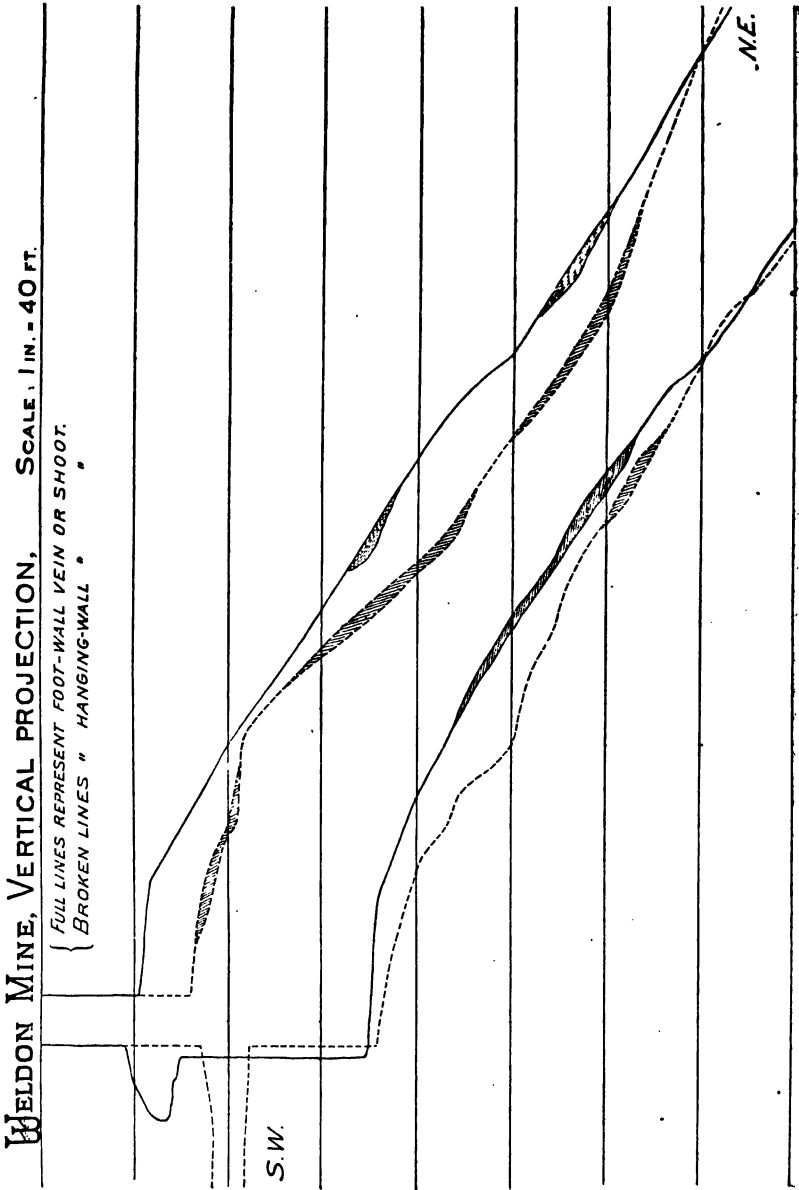
Shoots of ore nearly parallel and side by side, have been opened in the Weldon mine. This mode of occurrence is exceptional, unless the

intermediate rock be regarded as a horse, and the shoots, now separate, be found at a greater depth to unite. They are shown in the vertical projection on page 72, reduced from maps and sections of the mine. Both shoots pitch toward the northeast at about an angle of 35° , and at the bottom are only a few feet apart. The shaded parts of the diagram represent ore left on the bottom and cap rocks.*

The origin of the various phenomena of the structure of these Archaean rocks, as dip, strike, pitch, folds, faults and pinches, might involve a wide range of discussion. When it is remembered that this formation includes the oldest known stratified rocks, and that they have been subjected to the action of repeated uplifting and compressing forces, and to the wear of ages of exposure to the atmospheric elements, and, in part, to the subsequent denudation and abrasion of the glacial period, the complicated structure is not surprising, but an almost inevitable result. To retrace the steps in this long history is not altogether possible, in view of the scanty data in our possession. The probable mode of original deposition and the causes of the various phenomena of structure, are all that can be indicated at present.

These rocks are found in beds of varying thickness and extent, and, succeeding one another irregularly, as newer strata or even as very recent deposits, are seen to consist of alternating series of thick and thin beds. From their composition also it seems highly probable that they were laid down under conditions somewhat similar to those which affect the deposition of beds of sand, clay, marl and iron ores in recent times. And there must have been sandy, clayey, calcareous and ferruginous beds like these modern deposits in some respects. Uniform conditions may have prevailed over larger areas than they do to-day, as is proved by the extensive outcrops of rocks having the same general characters and composition. The lakes, marshes or basins in which the deposits of iron oxides or iron carbonates accumulated were of great length, and apparently of equally great breadth, and the deposition was long continued, forming thick beds, when they in turn were covered by other sediments. Thus the accumulation went on as the older strata gradually and slowly subsided until the thickness amounted to thousands of feet. The time was long, perhaps as great in length as the combined ages of all the later formations. With the subsidence of the beds, the agents, pressure, heat and water, came into action, producing the great changes wherein these fragmental sedi-

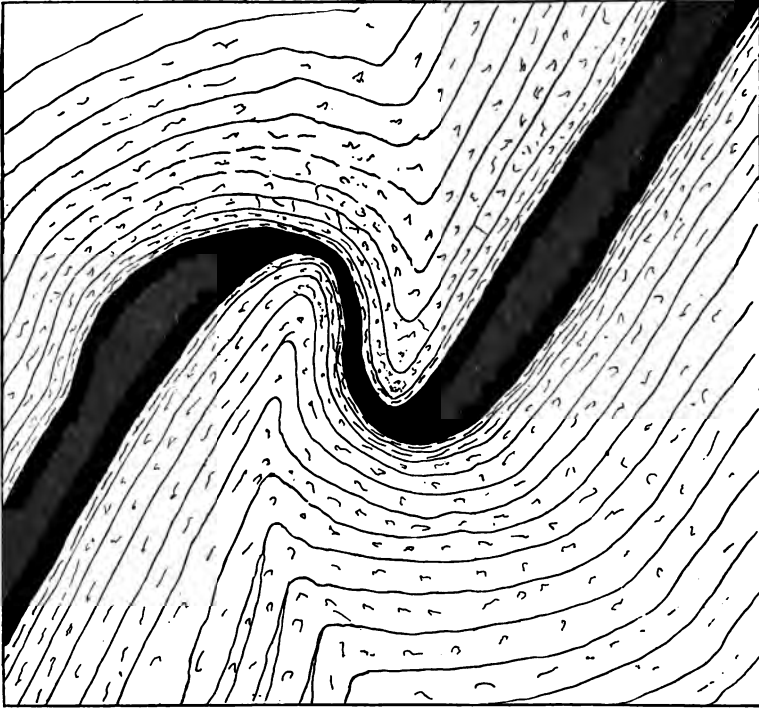
* The horizontal lines in the figure have no structural significance.



ments and fine deposits were altered into crystalline masses. This change or metamorphism of the strata was probably slow and in progress throughout a long period of time. The gradual subsidence also gave the strata more or less gentle inclination, and dip began as an element of stratification. Upheaving and compressing forces at length began their mighty work and the gently sloping beds were raised up along axial lines of great length into huge arches and depressed into deep troughs, and compressed by the powerful thrust of lateral forces into close folds, so that all the beds were brought into an approximately vertical position. And from the steeper inclination of the beds on the southeast, this thrust or horizontal compression was apparently greatest on that side. As already stated, the folding took place along northeast and southwest lines, and the lateral forces pressing the strata together was from the southeast side. But it is scarcely conceivable that such prodigious energy, exerted however slowly, confined itself to the folding in one uniform direction throughout the whole area of these Archaean rocks. The elevating forces may have acted very unequally and at greatly varying rate; and the inequalities thus caused, with differences in the nature of the bed, and compressing forces acting with varying intensity, would tend to disturb the symmetry and produce the diverse strike and dip which we recognize as exceptional to the general course and prevailing directions. Or a combination of lateral forces would produce the twists, as it were, in the strike. The northwest strike in the localities referred to on page 51, may be the result of bends or folds caused by pressure from the northeast or southwest and in the general lines of folding.

Varying intensity in the upheaving and folding forces would not only tend to produce diverse dip and strike, but also fractures and rents in the strata. The different degrees of firmness and elasticity in the strata themselves would aid in bringing out such fractures and dislocations. And faults would result from these causes. Lateral pressure exerted unequally upon a bed of uniform degree of elasticity and resistance would disrupt it along lines parallel to the line of pressure, or approximately so. Pressure in the line of the strike might pucker up the beds and sundering them let them slip past one another. An ideal illustration of the result of compression, exerted in the line of strike, producing partial folding and pinching in a more elastic bed, as iron ore, is here inserted. The solid black band represents a bed of ore, which with the adjacent gneissic strata, has been thus con-

torted and squeezed to a thin layer between the less elastic gneiss. We may conceive the squeezing process to have been carried so far as to pinch out the ore where the fold is seen and produce an apparent fault or offset in the once continuous bed. No doubt some of the so-called offsets are not simply lateral displacements or thrusts, but contortions of this kind.

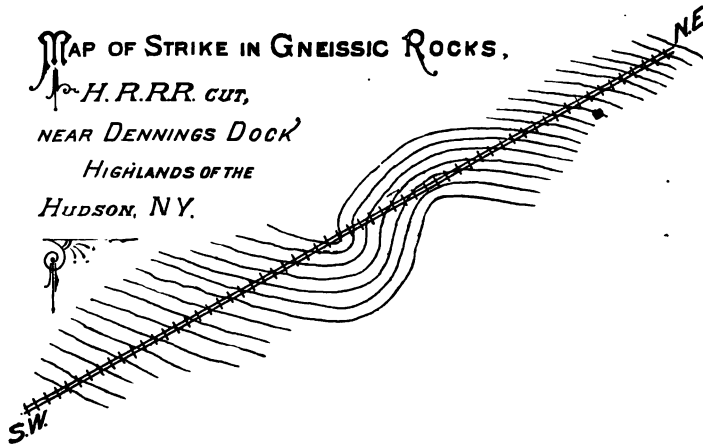


Plan of an Ideal Fold of Ore-bed and Gneiss.

A lateral fold or contortion apparently of this nature is seen at Dennings Dock, New York, a map of which is given on the following page.

Or, again, in the very close folding the beds of the arch might be shoved over upon the trough of its neighbor and whole succession of strata be faulted. Such faults as have been shown on page 65, probably had their origin in this way, whereas the more common lateral displacements or offsets were caused by unequal compression. The vertical faults, like that of the Hurd mine, which are so charac-

teristic of these rocks, appear to have been produced by the same agency as that which gave rise to the pitch. Unequal uplifting forces may have faulted the already vertical and folded beds on more or less parallel northwest and southeast lines, and depressed the northeast ends of each section so as to give rise to the *pitch*. A system of such



faults would account for the inclined axes of the folds and give the beds a descent in the line of strike in addition to the older inclination of dip. In general the faulting in these Archaean rocks is mainly in the lines of dip and strike and is probably the work of folding, compressing and uplifting agents.

These forces were doubtless the factors in the production of what has been styled the *shoot and pinch structure*. The ore beds possessing more elasticity than the adjacent and enclosing gneissic and syenitic rocks adapted themselves more readily to their action and accumulated in certain lines or horizons and in somewhat irregularly shaped bunches. Where the compression was less they would be thick; where more intense they would be squeezed into thin sheets, if not cut out. This pressure may have been in part, during the deposition of the succeeding beds over the ore, and caused by their superincumbent weight, which was unequally distributed. When the effect of heat also is considered, which might result from great pressure, the causes appear adequate to the production of great inequalities in one and the same bed. But the more probable theory is, that the uplifting and folding forces did more in giving shape to these ore bodies. Of course, the formation

of such sediments in shallow lakelets and marshes as bog and lake ores, or the deposition of carbonate of iron in the water of lagoons, might explain the lenticular shapes of the iron ore *veins*. And the succession of shoots in the case of many of our iron mines seems to agree with the theory of such a mode of original deposition—in a chain of small and partly connected bogs and lakelets. This origin determined the general direction and extent, but subsequent forces of uplifting, folding and compression must have greatly modified them and given them their present shape.

UNSTRATIFIED ROCKS, DIKES AND VEINS.

The preceding section was devoted to the description of stratified rocks, and the changes in their forms due to folding, faulting, compression and contortion under the action of various agents. There are other outcrops, and those in which stratification does not appear; and they are said to be massive. Here are classed the granitic, syenitic and trappean rocks. Their outcrops are so limited in extent that they form but a very small fraction of the whole surface of the Archæan, and their distribution in it is not represented upon our maps. There are no granitic axes or cores in our mountain masses. In fact, the largest known outcrops of granitic and syenitic rocks are scarcely larger than what may be considered as huge dikes. And it is uncertain as to the exact nature of some of the so-called granites. Further examination may show that they are stratified rocks, in which the bedding has been obliterated, and the faint parallelism in the arrangement of the minerals may give the clue to the bedding. The very indistinct marks of stratification in some outcrops of rocks known to be bedded, by quarrying and mining explorations, warns against a too hasty conclusion in favor of their supposed massive or unstratified structure. There are localities, however, where dikes of granite traverse or cut across strata of gneiss. Fine exposures are seen in the Pequest rock cut of the Delaware, Lackawanna and Western Railroad, near Pequest furnace, in Warren county; on the line of the New York, Susquehanna and Western Railroad, near Stockholm, but in Passaic county; on the same road, east of Charlotteburg; along the Sussex Railroad, one and a half miles east of Waterloo, (very beautiful sections of granite dikes, cutting a hornblendic gneiss); at Oxford, in Warren county, and along the Belvidere Delaware Rail-

road, at the end of the Pohatcong range. In the Bryant mine and in the Excelsior mine, north of Hackettstown, the ore worked was from what appeared to be ore-bearing dikes of syenitic rock. The Mitchell mine, near Port Murray, was much the same in appearance. In the Pequest mine and in the Naughtright mine, huge dikes were met with in following the ore, and they appeared to *cut it out* altogether in certain directions. Very beautiful examples and easily accessible sections can be seen in the Highlands of the Hudson, along the Hudson River Railroad, at Cold Spring and Beverly Dock, near Iona Island station, and near Peekskill, going towards Fort Montgomery tunnel. The above references are all to granitic or syenitic rocks. The number of localities could be readily increased, as small dikes of these rocks are common almost everywhere in the gneissic ranges. Trap dikes are not so frequently observed. The best exposed and most accessible locality of the latter class is seen in the buckwheat field opening of the New Jersey Zinc and Iron Company, at Franklin. There are at this place several narrow dikes, like great thin plates of rock, standing on edge across the zinc ore strata. The northeastern dike is, however, much larger (20 feet thick), and apparently increasing in size going down. In the Mount Olive mine a dike of very fine-grained trap-rock, only one to two feet thick, has been found running down almost vertically from near the surface to the bottom of the mine. Such narrow dikes do not seem to have affected the ores, either of iron or of zinc, to any marked extent. The larger granite or syenitic masses give trouble to the miner and appear to disturb more the regularity of the bedding.

The composition of these intrusive and unstratified rocks has not been studied. The facts of their occurrence have been collected. The study of the rocks is necessarily deferred to future reports.

VI.

IRON MINES.

Since the publication of the *Geology of New Jersey*, in 1868, notices of the discovery of new localities of iron ore and of the openings of mines have been given from year to year as these localities have been visited and data describing them have been received. But no systematic description of all the mines has been attempted each year. In 1873, the Archaean rocks, including the ranges of magnetic iron ore, were grouped in four geographical belts and the list of mines was published with notes of all the newer openings. During the business depression which followed the panic of 1873 and which continued until 1879, very few new mines were opened and the iron-mining industry was confined largely to the older and larger mines. The revival of business, in 1879, stimulated searches for ore, and many old openings and mines were reopened. And in the report for that year a list of the mines with notes appeared. It was republished in 1880, supplemented by descriptions of localities omitted in the preceding report. The notices of the iron-ore district, including local descriptions, are, therefore, in the reports for 1873, 1879 and 1880.

A review of the iron-ore district and a revision of the list have been attempted this year. The field work of the season was in part devoted to visiting the mines, so far as time would allow, and to collecting notes and data bearing upon the structure of the iron-ore bodies and their relations to the associated gneissic rocks. The facts about their working and the general condition of the iron-mining industry, or what might be called the economic geology of the iron-ore district, have also been gathered so far as was possible. All of the larger mines in Morris, Sussex and Passaic counties were visited. But a vast deal of information has come from mine superintendents and agents of the companies owning and working the mines, and from mine owners also. And the Survey is under great obligations to all

for the generous and prompt contribution of valuable material relating to the mines and the occurrence of iron ores in our Highlands. While the list of localities is believed to be full, the notes are in many cases scanty, and refer either to structural peculiarities or to their working. Full descriptions have not been attempted as the rocks and ores have not been studied nor analyzed. Hence, the report on the iron mines this year is incomplete and to be regarded as one of progress, or preliminary to a final report another year, when the whole district shall have been surveyed and mapped, and after examinations shall have been made of the ores and the rocks, and all the possible aid from mine surveys have been gathered to help in understanding the geological structure of the Highlands and the mode of occurrence of the magnetite in it.

It is desired that all mine owners, agents and superintendents or managers shall scrutinize the list and the notes, as well as the preceding sections of the report devoted to structure, and collect all available facts which may either confirm or refute the positions and statements here presented. It is only after a full discussion of all the facts that we can hope to reach correct conclusions and discover the true theory of these iron ore beds. And this result means the more rapid development of this mining district and the avoidance of losses incidental to wrong hypotheses. The year has not been a prosperous one in iron mining. The low prices in the early part of the year and the continued dullness through the latter part, intensified by the exceedingly slow market for ores at any prices, produced a depression which was felt by all and is manifested in the diminished output for the year. The aggregate tonnage of iron ore over the several railway lines, which transport very nearly all the ore that is mined in the State, is 521,416 tons, as compared with 932,762 tons reported in 1882. A noticeable change since 1881 is the decrease in the number of working mines. Only the more thoroughly equipped mines which are near transportation lines continue to be worked. Nearly all of the smaller mines have suspended working. Some of them have been permanently abandoned. And a few of the larger and deep mines also have been given up by lessees. The work of prospecting and of opening new localities also is at a stand-still. There is no motive or stimulus to start such work. And in the general stagnation of the market for ores new mines would not be able to compete for business, excepting at very low figures, unless they can furnish ores of extra quality and

are favorably located. And as the cost of mining is not much lessened by a reduction of the labor item, the margin left for the miner is narrow. In many cases the rates obtained barely cover expenses, including royalties, and some of the mines are thus kept in operation in order that the men may be kept, and to avoid the deterioration and loss to mine machinery, timber, &c., incident to stoppages for any length of time. Others which are worked on long leases are of necessity kept in working. In view of the low prices and the dullness of the market, managers are looking to all possible economies. And improvements in boilers, the use of cheaper fuels, greater economy in handling by means of mechanical devices saving labor, machine drills, more powerful explosives, and connection by switches with main lines so as to bring cars direct to the dumps, are all in use or in process of introduction. Many existing leases are on high royalties. And in these times when every possible source of economy is to be sought after, it would seem as if more favorable and easier terms ought to be had. Writing in the general interest of our mining industry, we think that royalties should fall so as to allow the land owner, who runs no risk, to bear his share in the general reduction of profits. In consequence of the long terms of many leases immediate changes are not always possible, or, perhaps, always desirable. Perhaps a sliding scale adjusted to prices of ore would be a more equitable arrangement. At the present time, royalties in our State are at an average rate of fifty cents per ton, ranging from twenty-five cents to one dollar. They are higher than in the iron districts of New York or Pennsylvania, and, of course, above the rates which prevail in less favorably situated ore regions. And this is one of the elements which is diverting the iron-mining business to other localities. It is, therefore, worthy of the serious consideration of our land owners and owners of mineral rights, who do not work their mines and who incur no expenses for equipment, means of transportation, cost of running and hazard no losses, and in many cases have no extravagant interest accounts, to ascertain if lower rates might not attract more business and be equally remunerative.

NOTE.—The order of the following list is that of the four belts, viz., Ramapo, Passaic, Musconetcong and Pequest. And in these groups the arrangement of the mines is from southwest to northeast. The references to notices or descriptions in previously published

reports of the Geological Survey follow the name or notes and are in smaller type. So far as is known, all the mines which have been at work during any part of the year have some notes to that effect or are more fully described. The absence of any statements whatever, indicates that the said mines have been idle. Many which have been abandoned are referred to on account of some items of interest pertaining to them.

RAMAPO BELT.

BERNARDSVILLE OPENING, Bernard township, Somerset county.

Annual Report, 1873, p. 24.

" 1874, p. 41.

JAMES MINE, Bernard township, Somerset county.

Geology of New Jersey, 1868, p. 544.

Annual Report, 1873, p. 24.

CONNET, or WATER STREET MINE, Mendham township, Morris county.

Annual Report, 1873, pp. 24-25.

" 1879, p. 41.

BEERS OPENINGS, Hanover township, Morris county.

Annual Report, 1878, p. 69.

" 1879, p. 41.

TAYLOR OPENINGS, Montville township, Morris county.

Annual Report, 1873, p. 25.

COLE FARM, Montville township, Morris county.

Annual Report, 1874, p. 21.

" 1879, p. 41.

KAHART MINE, Pequannock township, Morris county.

Geology of New Jersey, 1868, p. 544.

Annual Report, 1873, pp. 25-26.

" 1880, p. 101.

DE BOW PLACE, Pequannock township, Morris county.

Annual Report, 1873, p. 26.

" 1879, p. 42.

" 1880, p. 101.

LANAGAN MINE, Pequannock township, Morris county.

Annual Report, 1873, p. 26.

" 1879, p. 42.

JACKSON, or POMPTON MINE, Pequannock township, Morris county.

Geology of New Jersey, 1868, p. 544.

Annual Report, 1873, pp. 26-27.

" 1879, p. 42.

DE BOW MINE, Pequannock township, Morris county.

This mine was re-opened two years ago and worked for a short time by A. Z. Ryerson, of Bloomingdale. The vein was reported five feet wide.

Annual Report, 1873, p. 27.

" 1879, p. 42.

BEAM LOT, Pompton township, Morris county.

Annual Report, 1879, p. 42.

KANOUSE and BROWN MINES, Pompton township, Passaic county.

The northeast or Kanouse mine was opened many years ago, and a description of it appeared in the Geology of New Jersey. The Brown mine is a more recent opening of S. D. Brown, of Paterson. The Midvale Ore Company has expended a large sum in testing the property, putting up machinery and grading a branch railroad to the New York and Greenwood Lake Railroad. There are two main shafts, about 1,500 feet apart and 100 feet deep. From them drifts to the aggregate length of 600 feet have been cut in the vein, with a view to overhand stopping. The ore is said to range from eight to twenty feet wide. Several thousands of tons of ore have been mined and shipped to the Bethlehem Iron Company, at Bethlehem, and to the Pennsylvania Steel Works. The ore is low in phosphorus and adapted to the manufacture of Bessemer pig metal. The property is owned by Mrs. S. D. Brown and is held by the Midvale Ore Company. In view of the comparative scarcity of Bessemer ores in our State, it is to be hoped that this apparently large and accessible ore body will be further explored and develop into a permanently productive mine.

Geology of New Jersey, 1868, p. 545, (Kanouse mine.)

• Annual Report, 1873, p. 28. (Kanouse mine.)

" 1874, pp. 21, 22, (Brown mine.)

" 1880, p. 102.

SLOAT FARM, near Midvale, Pompton township, Passaic county.

The Sloat farm openings have not been described in any of the Survey Reports, as the first visit to the locality was in 1882. They are not new, having been made some years ago. The place is two miles northeast of Midvale station. There are four openings located on the eastern side of a steep, wooded ridge. The south pit was about twenty feet deep. The strata opened, consisted of gray gneiss with magnetite and of a hornblendic or syenitic gneiss also carrying magnetite. At the northernmost opening, where the most work appeared to have been done, the ore on dump was lean and much mixed with rock. The pit sides had so fallen in that the strata were not seen. In a third hole, and located on the ridge 250 yards northwest of the last described, a thin bed of good ore was uncovered at a depth of ten feet. The attraction about the openings was not very strong. The locality possesses interest as showing the occurrence of rich ore in a thin bed or vein and ore or magnetite in rock strata. No work has been done here since the place was visited.

BUTLER MINE, Hohokus township, Bergen county.

Geology of New Jersey, 1868, p. 544.
Annual Report, 1879, p. 42.

PASSAIC BELT.

LARGE OPENINGS, Clinton township, Hunterdon county.

Annual Report, 1873, pp. 28-29.
" 1879, p. 43.

ANNANDALE, or SHARP SHAFT, High Bridge township, Hunterdon county.

Annual Report, 1880, p. 102.

HIGH BRIDGE, or TAYLOR MINE, High Bridge, Hunterdon county.

Geology of New Jersey, 1868, pp. 617-618.
Annual Report, 1873, p. 29.
" 1879, pp. 43-44.
" 1880, p. 102.

SILVERTHORN, or KEAN MINE, High Bridge township, Hunterdon county.

Annual Report, 1879, pp. 44-45.

" 1880, p. 102.

" 1881, p. 37.

EMORY FARM, High Bridge township, Hunterdon county.

Annual Report, 1879, p. 45.

SHARP FARM, High Bridge township, Hunterdon county.

Annual Report, 1879, p. 45.

CREAGER PLACE, High Bridge township, Hunterdon county.

Annual Report, 1880, p. 102.

OLD FURNACE MINE, High Bridge township, Hunterdon county.

Annual Report, 1873, p. 29.

" 1879, p. 45.

" 1880, p. 102.

COKEBURGH MINE, Tewksbury township, Hunterdon county.

Annual Report, 1873, pp. 29-30.

BURRILL FARM, Tewksbury township, Hunterdon county.

This locality is one and a half miles southwest of Fox hill, or Fairmount, and a half mile westerly from the Mountainville road. It scarcely amounts to more than a trial shaft in search of ore; and it is nearly four miles from the nearest railroad station.

Annual Report, 1880, p. 102.

SUTTON FARM, Tewksbury township, Hunterdon county.

The last work which was done at this locality was two years ago, when about 200 tons of ore were raised from a new shaft located a few yards southeast of that put down by Mr. Sutton. The deepest working was only about 30 feet down.

Annual Report, 1873, p. 30.

" 1879, p. 46.

FISHER, or FOX HILL MINE, Tewksbury township, Hunterdon county.

Annual Report, 1873, p. 30.

" 1874, p. 22.

" 1877, pp. 49 and 50.

" 1879, p. 49.

WELCH FARM, Tewksbury township, Hunterdon county.

The openings for ore in this place have not been mentioned in any of the Geological Survey Reports. The locality is properly one of exploration, and not a mine. It is half a mile east-northeast of Fairmount, and is on lands of M. Beavers.

POTTERSVILLE, or UPDIKE FARM, Tewksbury township, Hunterdon county.

This locality is also known as the Potter shaft. It is west of Pottersville and south of the Fairmount road. The work was done in 1872-3, by the late A. Beemer, of Dover.

BARTLE SHAFT, Tewksbury township, Hunterdon county.

The explorations here also were made by Mr. Beemer in 1872-3. The *vein* was said to be 10 feet wide, and dipping steeply to the southeast. The ore was blue, hard, and carried some pyrite. Some ore was shipped.

WORTMAN SHAFT, Chester township, Morris county.

Another locality which was opened by Mr. Beemer, and about the same time as those above mentioned. It is two miles northeast of Pottersville, and on the east side of Black river. The depth reached (in two shafts) was 35 feet. The ore at the surface was red, and of good quality. A drawback to this locality and to the other localities near Pottersville, is the distance from railroad, the nearest stations being four to five miles away.

LANGDON MINE, Chester township, Morris county.

What is termed the Langdon mine is on the farm of Robert Pitney and is one and a half miles southwest of Hacklebarney. Attention was drawn to the locality by the magnetic attraction. And it was opened in June, 1880. The *vein* is traceable by means of the attraction a distance of 2,000 feet, from northeast to southwest, but it has not been opened more than 1,000 feet. The course is S. 35° W. (magnetic). Pits were first dug and the ore was worked open to day, but subsequently they were partly filled by timbers covered with earth to allow of underground work. The ore was found 3 to 12 feet beneath the surface. There are two shoots of ore which pitch toward the southwest at an angle of about 20°. The dip is at a moderate

angle toward the southeast. In the southwest shoot the workings have been pushed to a depth of 80 feet in the main (pump) shaft. The breadth of ore ranges from 10 to 15 feet. The hanging wall is very smooth and hard. The foot wall of the shoot is a soft rock. Drifting into it, another vein has been opened, which is three feet wide above and at least five feet in the sink. The horse of rock separating the main vein from this ore on the foot-wall side is between one and a half and two feet thick at the bottom and three to four feet above, nearer the surface. The latter ore is said to be rich; in the upper part it was soft. In the northeast shoot the vein is 11 to 15 feet wide and the deepest working is down 28 feet. Northeast of the pump shaft about 40 feet there is a lateral fault, or offset, in which the vein is thrown seven feet into the foot wall (looking northeast). Beyond this point and between the openings on the southwest and the northeast open cut a greater offset, and into the hanging wall side, is indicated by the sudden change in the course and nature of the attraction. The workings indicate a probable displacement vertically and there may be both a lateral and vertical faulting in this untested interval between the two shoots.

The top or surface ores, to a depth of 8 to 38 feet, were red and free from sulphur. The blue ore of lower workings carries some pyrite and mica in thin layers or laminae, resembling in these respects the Hacklebarney ores. For washing the red ore, the brook near the mine furnished the necessary water. One pump served to unwater the mine and the same boiler afforded steam for hoisting also. The ore was carted to the railroad at Hacklebarney at a cost of 40 to 47 cents per ton. The mining was done cheaply and profitably until the discontinuance in May, 1882, since which date the mine has been idle. With a revived demand for ore, or with railroad facilities at the mine, it can be worked profitably again.

L. W. Langdon & Son were the lessees.

Annual Report, 1879, p. 46.

" 1880, p. 103.

On the Pitney property, adjoining the Langdon mine on the northeast, a shaft was sunk near the line and a vein found 12 to 15 feet wide, also *pitching* to the southwest. The attraction is rather faint. The ore was mixed with pyrite and was lean. It has not been further tested.

PITNEY MINE, Chester township, Morris county.

The Pitney mine is on Robert Pitney's farm, northeast of the Langdon farm. The mining was done under a lease by Cooper, Hewitt & Co., in 1879-1881. The place was abandoned near the end of the latter year. The openings are in a northeast and southwest direction and not more than 100 yards long.

RARICK FARM, Chester township, Morris county.

Annual Report, 1873, p. 31.

" 1879, p. 46.

HACKLEBARNEY MINES, Chester township, Morris county.

The uninterrupted working of these mines of the Chester Iron Company has developed a great extent of ore, and afforded excellent opportunities for studying structural phenomena. A careful survey is necessary, however, to show the exact location of the numerous openings and their relations to one another. The great fault at Black river, the lesser offsets in the *veins* to the northeast of it, and the frequent alternations of ore and rock, both so plainly stratified, need a detailed survey to properly illustrate any descriptions of them.

The later mining on the hill to the southwest is reported to have opened a very good vein beyond the limits of the older surface workings.

In the coal house cut, the northeast breast is undermining the road, and it is 30 feet wide and 40 feet deep. This large shoot will doubtless be followed to the river, beyond which it appears to be faulted to to the southeast. In the same mine, at the southwest, a tunnel has been cut through the bottom rock to what is thought to be a separate and lower shoot of ore. On the west there is ore beyond the foot wall of this cut, and the limit of the ore belt in that direction has not been reached.

Northeast of the Black river, the deepest openings are now below water-level. A large amount of ore has been taken from these excavations in the hillside, and there is still a great thickness of ore left in the bottom and in the breasts. The lean ore beds have been left standing in some parts of these open cuts and in the mines, although in removing the workable ore much of it was necessarily taken out. The mining has been carried underground to the northeast from the old open cuts near the river. A feature of these openings is that there are so many strata or beds of ore interstratified with rock.

The bedded structure is very plainly marked. The average dip is at an angle of 65° towards the southeast. Rolls in the walls are met with which vary the angle of dip and pinch the ore. The pitch to the northeast is also apparent in these rock walls as well as in the shoots of ore enclosed by them. A beautiful example of faulting is to be seen at the northeast end of the westernmost cut or opening. The ore is thrown into the hanging wall (looking northeast) fully 30 feet. The break is straight and vertical in its plane, and at right angles to the course of the ore, or to the strike. Going northeast, the most persistent bed is known as the *tunnel vein*. It has been followed a long distance up the hill and on the southeast side of the main road. Its name is from a tunnel which is driven in the hill from the northwest, about 500 feet long. It is marked by its regular thickness and dip, averaging five to six feet in width, and dipping 55° to the southeast. On this sloping hill from the pond southeast and east to the George vein, there is a belt 800 feet wide, in which the surface diggings have opened several parallel veins or beds of ore. They are mainly confined to a belt east of the public road, and near the course of the tunnel vein. These trial pits are nearly all less than 30 feet deep; and the ore is found in rather narrow beds, dipping very regularly at about 55° to the southeast. Near the surface, it is red; deeper, it is soft blue, and all of it is broken up with the pick. The deeper exploration would find it more solid and hard, as in the deeper parts of the tunnel and George veins. The many surface pits have proved the existence of many parallel beds of ore. It will be interesting to watch the further explorations and ascertain whether they are distinct beds with well defined walls, or the parts of a large body of ore below, which near the surface fingers out, so to speak, or are separated by horses of rock.

The *George vein* is opened on the top of the hill, south of the road. Properly, there are three separate beds, with strata of rock between them, and dipping uniformly and steeply to the southeast. A shaft now being put down on this vein is 70 feet deep.

Proceeding northeast, the next openings are on a narrow belt, where the surface is owned by Cooper, Hewitt & Co., and the mineral rights belong to the Chester Iron Company. When visited in the autumn, three trial pits had struck the ore. In one of them the ore measured 15 feet in width, and was found within three feet of the surface. The red ore at the surface graded into soft blue going down, though quite

irregularly mixed in places. The stratification was distinctly marked in the strings of ore and rock at the top, and the well-defined walls at the bottom. All of the material was so disintegrated and soft that no blasting was requisite to break it up. The indications which these trial pits gave at that time were very promising of a large and regular ore bed.

The working of the Hacklebarney mines is conducted economically by using the water-power of Black river to do the hoisting and pumping from the large openings near it. All the red ores from the various surface pits are washed at the old mill site. The ordinary rotary cylinder washer is in use for doing this work. Lean ores lose about 25 per cent. in weight, in washing, while the richer grades lose very little.

A southeastern range of ore has been opened on this property by the company, and one-third of a mile to the southeast of the mines, near the river. The vein is said to be five feet wide. A wagon road has been built along the river to it from Hacklebarney. The product of these mines of the Chester Iron Company amounted in 1883 to 19,000 tons, a slight decrease, occasioned by the general dullness in the iron ore market.

Geology of New Jersey, 1868, p. 557.

Annual Report, 1873, pp. 35-36.

" 1879, pp. 47-49.

" 1880, p. 104.

GULICK FARM, Chester township, Morris county.

Adjoining the Hacklebarney mines on the northeast is the Gulick farm, on which there are two ranges of ore. That at the southeast is a continuation of the Hacklebarney southeast vein and is opened at the foot of the hill near a small stream, tributary to Black river. Three shafts have been sunk. At the southwest there are two whip shafts which open the ore bed. Going northeast an offset of about 30 feet into the hanging wall is observed, beyond which is the third shaft. The whole length as thus tested is 500 feet from the southwest to northeast. In the latter shaft, at a depth of 40 feet, the ore was replaced by a hornblendic gneiss, or syenitic gneiss, the walls apparently continuing uniform and dipping at an angle of 60° to the southeast. The replacement appeared to be sudden and complete, so far as could be seen at time of visit. It is possible that the replacement is only apparent and that the ore is thrown down by a cross slide or vertical

fault. The surface red ores found in these shafts, give way, going down to the soft blue variety.

The western or northwest range of ore on the Gulick property has been tested at several points by trial pits and shafts. They prove the existence of an almost continuous range or series of small shoots, although nearly all of them are too shallow to prove the size of these ore bodies. One of the most successful of these openings is that on the "flats" and near the former workings of the North Jersey Iron Company. A considerable quantity of soft blue, stratified ore was raised from it last summer. Thin layers or sheets of greenish, micaceous rock occur, interlaminated or banded with the magnetite in much of this ore. The main or whim shaft, on the hill a few rods west of the Hacklebarney road, is 75 feet deep. The ore in it ranges from one to six feet in width. Near the Chester Iron Company's line on the west and west of the "flats" shaft, the *vein* is *offsetted* into the hanging wall about 30 feet (looking northeast). Beyond this offset the test pits and shafts have discovered two shoots side by side. The ores found on this farm are red near the surface and soft blue at greater depths. Some of them contain a small percentage of green augite, and pyrite is common to all of the blue ores. Thus far the developments have been of a very interesting character. And it is to be hoped that the explorations will result in deep mining and show us the exact nature of the changes already observed so near the surface. The property is owned by Cooper, Hewitt & Co., and the mining explorations have been carried on under the superintendence of Sampson George, of Chester.

Annual Report, 1873, p. 36.

" 1879, p. 49.

CREAGER, or PEACH ORCHARD MINE, Chester township, Morris county.

This place, lying between the Gulick and the Hedges, is being further tested by L. W. Langdon, of Chester. It was abandoned in 1873 by S. George.

Annual Report, 1873, pp. 36-37.

HEDGES MINE, Chester township, Morris county.

Annual Report, 1873, p. 37.

" 1874, p. 23.

" 1879, p. 49.

DICKERSON FARM, Chester township, Morris county.

This property adjoins the Hedges on the northeast. The openings are on the northwest range, and are reported as being 80 feet deep. The shoots are said to be short. No work has been done since the panic of 1873. The engine and pumps have not been removed.

Annual Report, 1873, p. 37.

TOPPING FARM SHAFT, Chester township, Morris county.

The two Chester ranges of ore are opened on this property. The southeastern line is a continuation of the Sampson mine, and there are several openings in the red ore, which show a continuous bed from that mine southwest, nearly to the Chester Branch of the P. & R. R. Co. The shafts are not deep enough to test the size of the shoots below the surface ore.

On the northwest line, and 1,100 feet from the other range, Sampson George is sinking trial pits from the line of the Dickerson property at the southwest, for several hundred yards northeastward. One shaft, 60 feet from the property line, was 50 feet deep, and showed a breadth of five to six feet of ore. A second shaft, 150 feet to northeast, struck three feet of ore. The course as indicated by these shafts is, N. 45° E. The ore on this line and found in these shafts is banded with mica and carries some pyrite, resembling the Hacklebarney rather than the ores of the southeast range.

Annual Report, 1873, pp. 32-33.

" 1879, p. 46.

" 1880, p. 103.

SAMPSON MINE, Chester township, Morris county.

This mine is now opened on a length of 350 feet, from southwest to northeast, and the slope is 285 feet deep, measured on the foot wall or dip of the ore-bed. One large shoot has been worked out. The present workings are in a second and lower shoot. The dip varies accordingly as the walls roll, but in general it is to the southeast. In places where the foot wall *falls back*, the dip is to the northwest. And the irregularities are greater in the foot wall than in that of the hanging. The observed pitch is 22° to the northeast. The average thickness of the ore is eight feet; in pinches it diminishes to three feet. The mine is worked by S. George, for Cooper, Hewitt & Co.

The extension of the High Bridge Branch Railroad to Chester,

runs at the side of the shafts of this mine and the Cromwell mine, adjoining it on the north, making transportation rapid, and giving opportunities for economy in handling the ore.

Geology of New Jersey, 1868, pp. 537-538, (Skellenger.)

Annual Report, 1873, p. 33, (Skellenger.)

" 1880, p. 103.

CROMWELL MINE, Chester township, Morris county.

The Cromwell mine is on the Skellenger, or Sampson mine shoot, northeast of the latter. It extends northeast to the hotel property. The slope is reported to be 180 feet deep. At time of visit, in the fall, mining had stopped. The pumps were still going and it was said that operations were to begin again soon. It was worked by the Cromwell Iron Co., ——— Cox, contractor.

(See references under Sampson mine.)

HEDGES FARM, Chester, Morris county.

This property is traversed by the northwest range of ore west of Chester and northeast of the Topping place. The explorations on it have not, so far, been very successful in finding ore.

CREAMER FARM, Chester, Morris county.

The Creamer farm also is crossed by the northwest ore range, but no developments have been made since last reports.

Annual Report, 1873, pp. 31, 33.

HOTEL PROPERTY, Chester, Morris county.

Annual Report, 1873, p. 33.

" 1879, p. 46.

COLLIS SHAFTS, Chester, Morris county.

Annual Report, 1873, pp. 31, 33.

SWAYZE MINE, Chester township, Morris county.

The Chester Iron Company has mined a large amount of surface ore from this vein, and has opened it up to the Cooper, on the northeast, making a long line of continuous ore. Work here was suspended last May, and the mine is now idle.

Annual Report, 1873, pp. 33-35.

" 1879, p. 47.

COOPER MINE, Chester township, Morris county.

The continued working of this mine has resulted in a large product of good ore, and opened some peculiar structural features, which are further noticed under head of "exploring for ore." From the Chester Iron Company's (Swayze) mine, on the southwest, the workings show an unbroken line for 1,465 feet, or to the offset northeast of No. 4 slope. A very large amount of red ore was obtained from it by means of open pits. The average depth of these surface workings was 50 feet. Here the ore was found quite flat and in broad shoots. As it could be got out by use of picks, mainly, it was mined at a low cost. All of the working is now underground, and there are four slopes, which follow the ore, descending at an average angle of 45° , on the foot wall. The pitch of the bottom rock, southwest of slope No. 3, and within 30 feet of No. 2, is at an angle of 25° towards the northeast. The rock on the ore in slope No. 4, which is supposed to be the cap over this large shoot, also pitches to the northeast. A centrally located engine affords the power for hoisting in all of them. Cars run in three of them; in the fourth buckets are used. The construction is such that they dump automatically at the head of the slope, thus avoiding as much as possible handling of the ore. The vein is less regular at the southwest, and the explorations in slope No. 2, 300 feet northeast of the property line, already referred to, show a strange and inexplicable occurrence of ore in the foot wall and in the bore holes, nearly in the course of the shoot, prolonged. The ore was cut out in the slope at about fifty feet from the surface, and a greenish colored, hornblendic rock appeared to take its place on the foot wall side, and at length across to the hanging wall, which retained its average dip to the southeast. The slope was carried down to a depth of 150 feet from the surface, and then short horizontal drifts were put into hanging and foot walls, and subsequently three bore holes were put down at angles of 40° , 50° and 60° , respectively. The ore found in Nos. 1 and 2 are nearly in the plane of the dip of the ore bed prolonged downwards, and the most plausible theory is that they pierced a lower shoot of ore, separated by an exceedingly narrow pinch from the ore body worked in the upper part of the slope. The ore in the so-called *foot wall vein*, is not, probably, connected with this lower shoot.

Northeast of No. 4 slope, there is an offset of 40 feet, at a depth of 70 feet from the surface. Its plane dips southerly, and is oblique to

the line of dip. The displacement of the ore is toward the hanging-wall side, looking northeast.

As in the mines near Chester, generally, the bedding is plain, and especially near the surface. In slope No. 3, the planes of bedding are finely exhibited, and there is on the foot wall side a thickness of nine feet of stratified ore, then rock two feet, followed by ore two feet thick. The presence of a large percentage of mica in the rock, and in thin laminae with magnetite, in the ore, tends to make the bedding appear prominent.

The extension of the Chester Branch of the P. & R. R. R. to the mine, affords every convenience for loading the ore directly from the mine cars into the ore cars of this line.

The total product for the three years of this mine's history, amounts to 60,000 tons. It is worked by the Cooper Mining Company, and under the management of John D. Evans, of Chester.

Annual Report, 1879, p. 47.

" 1880, pp. 103, 123.

KEAN MINE, Chester township, Morris county.

The Kean property adjoins the Cooper on the northeast. And it occupies a length of 2,000 feet on the course or strike of the vein. The ore is very much like that of the Cooper mine; near the surface red and free from sulphur; deeper, a blue variety and carrying a small percentage of pyrite. The most remarkable structural feature is a succession of pinches due to flattening of the walls. Mr. Evans, who has charge of the mining here, reports six of these "offsets" or pinches within a horizontal distance of 54 feet, and which have thrown the vein 58 feet into the hanging wall. The property is owned by John Kean, F. A. Potts, and estate of Francis Lathrop.

SQUIER'S MINE, Chester township, Morris county.

Annual Report, 1880, p. 103.

LEAKE MINE, Chester township, Morris county.

This old mine was reopened and worked in 1882 by the late A. Beemer, of Dover. It reached a depth of 80 feet and the vein was reported to be five to eight feet wide. The northernmost openings are now known as **SKELLENGER'S MINE**. They were going in 1881 and 1882. All have been idle the past season.

Geology of New Jersey, 1868, p. 558.

GEORGE SHAFTS, Chester township, Morris county.

Annual Report, 1881, p. 36, (Chester mine.)

CHILD SHAFT, Chester township, Morris county.

This locality is one mile south of Chester, and two-thirds of a mile east-southeast of Hacklebarney. Some ore was opened here in 1874 in the exploring shaft sunk by the Lehigh Valley Iron Company. No further exploration of the property has been made.

HARDEN FARM, Chester township, Morris county.

Annual Report, 1873, p. 32.

WOODHULL MINE, Chester, Morris county.**BUDD MINE, Chester, Morris county.**

The two last named mines have been abandoned and all the machinery removed.

Geology of New Jersey, 1868, p. 558.

Annual Report, 1873, p. 32.

" 1879, p. 46.

QUIMBY'S MINE, Chester township, Morris county.**TIGER'S MINE, Chester township, Morris county.**

These openings are one-fourth of a mile apart on a northeast line, and about a third of a mile southeast of the Woodhull-Budd vein openings. The vein in the Tiger property is reported as being three feet wide, but the ore was found in bunches and was sulphurous. About 300 tons were mined here. More work was done and more ore raised on the Quimby place, but no statistics were obtained. Both places have been idle for some time past.

DE CAMP SHAFT, Chester township, Morris county.**DANIEL HORTON MINE, Chester township, Morris county.****BARNES MINE, Chester township, Morris county.**

No work has been done at any of these localities during 1883.

For previous notes, see Geology of New Jersey, 1868, p. 558, for BARNES; also,

Annual Report, 1873, pp. 38-39.

" 1879, p. 49.

LEWIS, or HERRICK MINE, Randolph township, Morris county.

Annual Report, 1873, p. 42.

" 1879, p. 50.

COMBS MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 550.

Annual Report, 1879, p. 50.

" 1880, p. 104.

THORP MINE, Randolph township, Morris county.**HENDERSON MINE, Randolph township, Morris county.**

Geology of New Jersey, 1868, p. 558.

GEORGE, or LOGAN MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, pp. 558-559.

Annual Report, 1879, p. 49.

DAVID HORTON MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 559.

Annual Report, 1873, pp. 39-40.

" 1879, p. 49.

DEHART MINE, Randolph township, Morris county.**LAWRENCE MINE, Randolph township, Morris county.**

These mines are now leased by Samuel M. Keiper, of New York city, and worked for him by John Gordon, contractor. They have been in operation for two years. Most of the work is confined to raising the red ore from near the surface by means of open pits and by shallow underground shafts and drifts. The principal openings are southeast of the old mine shafts of the DeHart place. The red ore runs down to an average depth of 30 feet below the surface. It is found to be 6 to 18 feet wide, striking to northeast and dipping almost vertical to the southeast. The walls are rotten rock, and hence much timbering is needed; but the ore is broken up mostly by pick and without using much powder. Below this red ore and over the hard blue ore is an intermediate grade or mixed blue and red variety. The blue ore contains some pyrite, and to the northeast there is said to be a broad vein (50 feet across) of magnetite and pyrite which is too sulphurous for smelting and is not mined. It was opened about twenty years ago as a "copper mine," but soon abandoned, as it so

largely contained iron pyrites and with scarcely any chalcopyrite or copper pyrites. It might be utilized, possibly, for its sulphur in the manufacture of sulphuric acid.

The red ores of these mines, as well as some from the Horton mine to the southwest, are washed by water obtained through pumps still in the old shafts. They are carted to Succasunna and there shipped to various blast furnaces. Of course the limit of this surface weathered and red ore will soon be reached, as it does not extend much below the depth of ordinary open pits or cuts. Its excellence is attested by the sale it finds even in these dull market times. The blue ore can hardly be said to have been fully tested in these mines on account of the highly sulphurous ore which appears in such force, particularly to the northeast. The query is, Will it not improve as an iron ore at a greater depth?

Geology of New Jersey, 1868, p. 559.

Annual Report, 1873, p. 40.

" 1879, p. 49.

" 1880, p. 104.

DALRYMPLE, or CARBON MINE, Randolph township, Morris county.

Work at this locality was suspended in June, 1882. It was worked by the Lehigh Crane Iron Company up to that date.

Geology of New Jersey, 1868, p. 559.

Annual Report, 1873, pp. 40-41.

" 1879, pp. 49-50.

" 1880, p. 104.

TROWBRIDGE MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 559.

Annual Report, 1879, p. 50.

SOLOMON DALRYMPLE PLACE, Randolph township, Morris county.

COOPER PLACE, Randolph township, Morris county.

MUNSON'S MINE, Randolph township, Morris county.

Geology of New Jersey, 1868, p. 551, (Munson's mine.)

Annual Report, 1873, p. 42.

" 1879, p. 50.

VAN DOREN OPENINGS, Randolph township, Morris county.

Annual Report, 1879, p. 80.

BRYANT MINE, Randolph township, Morris county.

The Bryant mine stopped in April, 1883. From John D. Evans, of Chester, who had charge of the working, we learn that there were five slopes, the deepest of which, No. 1, went down on the bottom rock 735 feet. The pitch was at an angle of 25° toward the north-east, and the dip about 60° southeast. The shoots of ore were generally small, ranging from 10 to 25 feet in height, and two to six feet wide. Fifteen of them had been worked out. The ore did not *cut out* altogether, but *pinched* to few inches in the cap and in the bottom. The ore averaged high in metallic iron and contained very little sulphur. During the seven years' management of Mr. Evans for the Bethlehem Iron Company, the aggregate product was at least 25,000 tons. The machinery is about to be removed and the mine abandoned, as the most accessible ore has been nearly all taken out.

Geology of New Jersey, 1868, p. 566.

Annual Report, 1880, p. 104.

CONNOR FOWLAND MINE, Randolph township, Morris county.**CHARLES KING MINE**, Randolph township, Morris county.**KING MINE**, Randolph township, Morris county.

This mine was worked by John M. D. Barnes, under lease of A. Pardee, up to January, 1879. It has been idle since that date.

McFARLAND MINE, Randolph township, Morris county.

This mine has been idle for years past.

EVERS MINE, Randolph township, Morris county.

This mine stopped April, 1883. The last work done there was by the Saucon Iron Company.

The veins opened in these mines, between the Bryant and the Dickerson, are generally narrow. The ores are rich and of good quality, and they are worked advantageously whenever a brisk demand for ores makes the prices remunerative enough to pay for the extra cost attending their extraction.

For notes of these five mines, see references as follows:

Geology of New Jersey, 1868, pp. 566-567.

Annual Report, 1873, p. 43.

" 1879, p. 50.

" 1880, p. 105.

BROTHERTON MINE, Randolph township, Morris county.

The lease of the Brotherton mine was abandoned by the lessees, Messrs. Pullman & George, last fall. No ore has been mined or shipped during the past year.

Geology of New Jersey, 1868, p. 567.

Annual Report, 1879, p. 50.

" 1880, p. 105.

BYRAM MINE, Randolph township, Morris county.

The Byram-Russell slopes of this old mine were abandoned in 1882. The greatest depth reached was 1,100 feet, measured on the slope, whose dip was at an average angle of 60° toward the southeast. The ore at the bottom was of excellent quality, but the vein was narrow and the shoots were short. The heavy expenses in raising a large quantity of mine water and the ore from this great depth made the working no longer possible at a profit. The cost of the ore toward the last was in excess of its marketable value.

The slopes on the southeastern or hanging-wall veins and near the Mount Fern road, were worked until the close of the present year when they also were abandoned. The pump and engines are being removed to the company's Lower Wood mine, at Hibernia, and, the slopes are filling with water. Thus ends the working period of one of the historic mines of our State. The total ore shipments from this mine since October, 1870, amounted to 157,376 tons.*

Geology of New Jersey, 1868, pp. 567-569.

Annual Report, 1873, pp. 43-44.

" 1879, p. 51.

" 1882, p. 70.

BAKER MINE (SOUTHEAST), Mine hill, Morris county.

Geology of New Jersey, 1868, pp. 569-570.

Annual Report, 1879, p. 52.

MILLEN MINE, Mine hill, Morris county.

Geology of New Jersey, 1868, pp. 564-565, (Millen mine.)

Annual Report, 1879, p. 51.

" 1880, p. 105.

* Letter of Richard George, Esq., of Dover, superintendent and agent of the Andover Iron Co.

RANDALL HILL MINE, Mine hill, Morris county.

The Randall Hill mine is another of our large mines which has apparently ended its working period. The pumps were taken out of the deep slope in October, 1881. A little work, taking out surface ore, was done up to February, 1882.

Geology of New Jersey, 1868, p. 570.

Annual Report, 1879, p. 51.

" 1880, p. 105.

" 1882, p. 70.

JACKSON HILL MINE, Irondale, Morris county.

Geology of New Jersey, p. 570.

Annual Report, 1879, p. 51.

BLACK HILLS MINE, Ferromont, Morris county.

The Black Hills mine was worked under a lease to A. Pardee until June, 1883. It is owned by the Dickerson-Suckasunny Mining Co.

Annual Report, 1879, p. 51.

" 1880, p. 105.

DICKERSON MINE, Ferromont, Morris county.

This oldest and most widely known of the iron mines of our State continues to be actively worked under a lease by A. Pardee from the owners, the Dickerson-Suckasunny Mining Company. Three independent shoots of ore are worked, viz., the Cow Belly mine at the southwest, the Big mine in the middle, and the Side Vein at the southeast. These shoots are remarkable for their irregularity, and descriptions without the aid of illustrations and maps are scarcely possible. One peculiarity is in the varying strikes of the shoots. Thus, the Cow Belly mine lies more nearly in an east and west line than the main or Big mine shoot. Another feature is the apparent twist or change in the strike in the upper part of the Side Vein. As opened south of the Big mine, the drifts and shaft show a general northwest and southeast course to a depth of 120 feet, and on a length of 100 feet. The *vein* is narrow, and the dip is toward the northeast, at a moderate angle. At a depth of 120 feet there was a northeast and southwest *vein*, four feet in width, and dipping to the southeast, and crossing the one which had been followed from the surface down. The occurrence is so extraordinary that it is here referred to, though no explanation can be given, unless there is a twist in the shoot at

this horizon. As the northeast and southwest shoot was not seen in the upper 100 feet, it does not seem at all probable that the two are separate and true veins crossing one another. Still, for 30 feet, and to a depth of 150 feet, they have both been worked on, though the northeast shoot is short.

The greatest depth reached in any part of the mine is in Big mine heading. The slope is 1,100 feet long, and descends in a northeast direction at an angle of 48° , then 38° , and again steeper near the bottom. The vertical depth is 700 feet below the office. The bottom of the Cow Belly mine is nearly as deep (according to barometric observations). The Side Vein mine is not as deep, and the new vertical shaft will strike this shoot 180 feet above the bottom of the Big mine.

The Cow Belly mine is opened direct to the surface by its own slope and skip-track coming out through the "cave" and southwest of the Big mine. It is connected with the latter by a horizontal drift. This ore-body is said to have been the most irregular in shape. Formerly, it was very large. When visited, the walls appeared to pinch the *vein* at the southwest; and at the northeast, the shoot, though still broad, included some beds of rock interstratified with the ore. The length from bottom rock to cap rock has also diminished. The pitch is to the northeast; the walls show an average dip of 60° to the southeast. But as the ore is rich, and as there is little water to contend with, and a probability that these pinches are followed by lower shoots or larger swellings of the ore-body, the mine is kept steadily going.

The Big mine shoot also has varied much in its dimensions. Its average pitch to the northeast is at an angle of 45° ; its walls show a dip of 55° – 60° to the southeast. The new slope which runs to the bottom and through the center of "Broadway," or the largest part of the mine, is due northeast in its course, *easting* a little near the bottom. This shoot, at the horizon of its greatest area, and in what is termed "Broadway," was 78 feet long and 60 feet broad. The working area, or horizontal section at the bottom, is 225 feet long (from southwest to northeast, or from bottom rock to cap rock), and 18 feet wide (from foot wall to hanging wall). These dimensions indicate a great change in the shape, though the area of the cross section is very nearly as great as it was above when the shape was more nearly square. But the bottom rock is not properly the limit of the ore, as some ore is left on the hanging wall side in a thin stratum

or *leader*, but too narrow to work with profit. The same is true at the northeast, in the cap rock. The latter, however, is said to retreat more irregularly than the foot wall. And the superintendent, Mr. Potter, observes that the pinches are due to the inequalities in the foot wall, which comes in and squeezes the ore both at the bottom and at the cap. The workings follow the irregularities as far as the ore is found of a workable size, down to one or two feet in breadth. In the bottom of this mine the inter-stratification of the mass of ore, with some layers of rock, is very evident. But where the *vein* is pinched very much, the prismatic structure of the ore looks more like that of a dike of trappean rock. The ore of this big shoot in the higher levels consisted of two well-marked varieties: a coarse, granular, or shot ore, on the Potter, or foot-wall side, and a fine crystalline ore on the east, or Broadway part of the mine. A horse of rock then separated these two distinct varieties. Now the ore is much more uniform in its appearance and in character. It is still noted for its high percentage of metallic iron, carrying scarcely any foreign minerals. This mine differs from the Cow Belly in being much better, and a steam engine is necessary in the mine to force water to surface. The ore is raised in cars which run on the covered slope track to the surface. Machine drills, driven by compressed air, facilitate the breaking down of a large amount of ore.

The Side Vein is on the southeast and hanging-wall side of the Big mine. The pitch of this shoot is, in the lower workings, to the northeast. The peculiar crossing of veins near the surface has already been mentioned. The general shape of this shoot is described by the mine superintendent as transverse to that of the Big mine, and from northwest to southeast. The horizontal cross sections on the levels, 478 and 548 feet (vertical depth), show a straight foot wall on the west-northwest, and an easterly and southward curving cap rock and bottom rock. Here it looks as if the ore-body were partly wrapped over a half cylinder of rock. The greatest dimension is from northwest eastward and southward. From bottom rock to cap rock the distance is only four or five feet. And the latter, in places, looks as if it were a horizontal bed of rock; while further to the east it rolls over and resumes its normal southeast dip and northeast pitch. As the ore becomes very narrow on the southeast it is not followed, and its exact shape is not known. At the bottom the cross section is almost T shaped. The ore of this shoot is rich, like that

of the rest of the mine. The slope running down on the foot or bottom rock is connected above by a drift, which runs a westerly course, crossing the strata for 90 feet, with the Big mine slope. The ore goes out that way. The volume of water here is much less than in the Big mine.

The Dickerson-Suckasunny Mining Company is sinking a vertical shaft a few rods northeast of the old Dickerson mansion, and northeast of the mine entrance, office, &c. It is intended to cut through the Side Vein at about 180 feet above the Big mine, and to strike the cap rock of the latter not far from the present heading or end of slope. The depth is calculated to be nearly 800 feet. This shaft is to be divided into compartments for the pumps and for the hoisting cages. And it will, no doubt, greatly increase the capacity of the mine by facilitating the raising of the ore and the rapid movement of the men in and out of the mine. Most of the ore is shipped to the furnace at Stanhope; a portion of it is sold for fettling.

These shoots of ore, while they show evidence of stratification, look so irregular as to favor the theory of their deposition in deep hollows or basins, or great injected masses; but a more probable inference is that they were thus distorted and compressed by some unequally acting agencies during their upheaval and alteration from a horizontal position and sedimentary nature.

Geology of New Jersey, 1868, pp. 570-574.

Annual Report, 1879, pp. 51-52.

" 1880, pp. 105-106.

CANFIELD PHOSPHATIC IRON ORE DEPOSIT, Ferromont, Morris county.

Annual Report, 1871, pp. 34-38.

" 1879, p. 51.

CANFIELD MINE, near Vannatta station, Morris county.

Annual Report, 1873, pp. 42-43.

" 1879, p. 52.

BAKER MINE (IN SWAMP), Vannatta station, Morris county.

The lower Baker mine, as it is also designated, is in the low ground at the western foot of Mine hill, and on the level of the plains. Mining operations were suspended here in 1883 on account of the leanness of the ore. The average percentage of metallic iron is reported as

ranging from 35 to 40, with phosphorus low enough to make it a Bessemer ore. Like so many of our ores available for Bessemer, it is quartzose, the silica in it varying from 5 to 40 per cent. Sulphur is present in traces only. The maximum depth of the mine is 300 feet. The Lackawanna Iron and Coal Company own it.

Annual Report, 1880, p. 106.

BAKER MINE (ON HILL), Mine hill, Morris county.

The mine, northeast of the last mentioned and on the north of the McCainsville road, is known as the BAKER-ON-THE-HILL. It also is owned by the Lackawanna Iron and Coal Company. The ore is rich and the vein is said to average six feet in width. It has been idle for several years.

Geology of New Jersey, 1868, p. 575.

Annual Report, 1879, p. 52.

" 1880, p. 106.

IRONDALE MINES, Irondale, Morris county.

The present operations at Irondale are confined to the northeast shoots of the STIRLING mine, now known as No. 13. The CORWIN MINE at the southwest is not worked. Between it and the Stirling there is an interval of 700 feet in length, where the *vein* is lost. From the offset in the Corwin, 75 to 80 feet to the southeast, and from the more southeast position of the Stirling outcrop at the southwest slope, it has been supposed that the vein would be found, not in the range or strike of the Corwin going northeast, but somewhere southeast of that strike prolonged. The map on page 151 shows the line of outcrop of the main Irondale vein and the offsets and courses here mentioned. An adit tunnel was driven in a northwest course from the brook level on the southeast, without finding ore. Test pits and shafts also have been sunk, but without success. It appears as if the *vein* was pinched out, or that there is a gap of barren ground between the Corwin shoot and those of the Stirling. The shoot which is now worked in No. 13 MINE is large and long, and has been the stay of Irondale for years past. Its height is 120 feet and its average breadth 10 feet. The slope descends on the foot wall in the line of the dip 380 feet, then runs northeast on the bottom of the shoot about 600 feet. The dip varies according to the rolls in the wall, but may average 40°, and to the southeast; the *pitch* of the ore is 17° to 18° toward the northeast. The vein at the bottom is pinched to a width of about a foot, where

the working stops. The walls are subject to rolls, and it is observed that where the foot rolls the *vein* widens, whereas, when the roll is in the hanging wall, it is pinched. And these rolls, of course, pitch to the northeast and make the shoots or irregular bunches of ore. The wall-rocks are mixed with ore to some extent. That on the foot is a hard, gray, feldspathic gneiss; the hanging is more micaceous and hornblendic. The ore itself has a little feldspar irregularly disseminated through it, also a green mineral (augite?). It is, however, rich, and is liked by the lessees, who use it at their Catasauqua furnaces.

In order to strike a lower shoot, below that of the main North River mine, and also to test the northeast extension of the No. 13 mine, two diamond drill holes have been put down in the low ground 385 and 415 feet, respectively, southeast of the outcrop of the North River. No. 1 boring went through four feet seven inches of ore at a depth of 338 feet. No. 2, 30 feet southeast of No. 1 hole, passed through fifteen feet six inches of ore at a depth of 365 feet. The holes are vertical and the figures here given are vertical measurements. The results of these trials are very encouraging as they prove the continuation of the shoot of No. 13 to the northeast and under the North river. The third bore hole was located 370 feet southeast of the Stirling outcrop and 840 feet northeast of the end of the same mine, or the gap between it and the Corwin. It was driven to a depth of 501 feet and no ore was encountered in all this distance. A possible explanation of this failure to discover ore, is in the location of the hole so far to the east that the gentle pitch of the upper shoots of the Stirling *carries* the vein to the northeast of it. The hole pierces the barren ground, or pinch (it may be) below and following northeast the Stirling shoot. It proves a great thickness of strata destitute of all ore and that where it might have been expected.

The HARVEY MINE, northeast of the North River offset, is idle. And the only work in progress in the HURD MINE, northeast of the Harvey, is limited to the removal of pillars from the upper part of the mine.

It should be remarked here that the North River offset is toward the west, or into the foot wall, looking northeast, the reverse of that in the Corwin mine. It amounts to 130 feet.

The Irondale mines belong to the New Jersey Iron Mining Company, L. C. Bierwirth, of Dover, agent. They are leased to the Thomas Iron Company.

ORCHARD MINE, Port Oram, Morris county.

The Orchard mine has reached a depth of 700 feet, measured on the slope; and the length on the vein, as worked, is nearly 1,000 feet. There are no offsets in it, or pinches which *cut out* the ore, although the shoot structure is found well developed. The Orchard and Iron-dale adit proves to be of great service in unwatering the upper part of the mine and in relieving the pumps. This mine is owned by the estate of J. Cooper Lord. It was driven last year, producing as much as 3,000 tons a month, for a time; but the average rate of production is not much over 1,000 tons monthly. The ore is rich and finds a ready sale. Gen. J. S. Schultz, of Boonton, is the manager.

Geology of New Jersey, 1868, p. 578.

Annual Report, 1879, p. 54.

" 1880, p. 106.

ERB MINE, west of Mine hill, Morris county.**SCRUB OAK, or DELL MINE, west of Mine hill, Morris county.**

These mines have not been at work during the year.

The last ore raised from the Scrub Oak mine was in the summer of 1881, when 820 tons were raised by the property owners, the Andover Iron Company. The ore-body is large, but the rock in the ore makes it lean. This *vein* appears to belong to the same range as the Canfield and Swamp Baker mines, and one which is characterized by lean siliceous ores, but low in phosphorus, and adapted to Bessemer pig manufacture.

Geology of New Jersey, 1868, p. 596.

Annual Report, 1873, p. 43.

" 1879, p. 54.

" 1880, p. 106.

J. D. KING MINE, near Port Oram, Morris county.

Annual Report, 1873, p. 43.

JOHNSON HILL MINE, near Port Oram, Morris county.

Geology of New Jersey, 1868, p. 596.

Annual Report, 1873, p. 46.

" 1879, p. 54.

HOFF MINE, near Port Oram, Morris county.

This mine was abandoned by the lessees, the Andover Iron Company, in July, 1883.

Geology of New Jersey, 1868, p. 597.

Annual Report, 1873, p. 46.

" 1879, pp. 54-55.

" 1880, p. 106.

DOLAN MINE, Mount Pleasant, Morris county.

This mine, named from its owner, Bishop Dolan, is under lease to Joseph Wharton, of Philadelphia, and is being re-opened. A tunnel is to be driven in to strike the vein.

Annual Report, 1873, p. 46.

" 1879, p. 55.

WASHINGTON FORGE MINE, Port Oram, Morris county.

The Carbon Iron Manufacturing Company worked this mine to the property line, since which time the *vein* has been opened by a new shaft, located a few rods northeast of the old one, and on the lands belonging to the J. Cooper Lord estate. Between them there is a fault where the vein is offsetted into the hanging wall (going northeast) about 10 feet. The new shaft is 108 feet deep, of which depth 33 feet is vertical. The interval of unopened line between this mine and the western part of the old Mount Pleasant mine is about 700 feet. This new mine of the Lord estate is sometimes known as the West Mount Pleasant, while the old mine on Mount Pleasant is termed East Mount Pleasant.

MOUNT PLEASANT MINE, Mount Pleasant, Morris county.

The *vein* in this mine has been opened a long distance. Southwest of the engine shaft, which is near the turnpike, it has been traced and worked more or less for 2,000 feet. And to the northeast the extreme stoping is 800 feet away, and half way across under the swamp which borders the hill of Mount Pleasant on the northeast. The depth there is now 400 feet. The total length, of what is probably one *vein* of ore on this property, is nearly three-fourths of a mile. The greatest vertical depth reached is 500 feet. Five shoots of ore are now being followed down on their pitch to the northeast. Their average height is 60 feet, with pinches of 2 to 40 feet wide separating them. The latter are also traversed by faults or *cross slides*, and they

make good pillars between the shoots. The breadth of ore which is mined varies somewhat, but averages about eight feet. The dip is to the southeast and at an average inclination of 57° ; the pitch, to the northeast, is at a considerably lower angle. The mine is remarkable for its offsets and cross slides. In the western part of the mine the *vein* is offsetted both ways by several faults which displace it a few feet. A figure in the *Geology of New Jersey*, 1868, represented them. Near the brow of the hill, south of the road, the displacement amounts to 66 feet. The courses of these offsets are in all cases nearly at right angles to the ore bed. A fine example of a lateral or side faulting is seen in the Eastern mine and 600 feet northeast of the slope and at a depth of 450 feet. The displacement is four feet, the breadth of the ore five feet, so that the continuity is not entirely broken. Its plane or course is right across the *vein* and is nearly vertical. The most marked displacements are the up and down, or the cross slides. They have been figured and described on page 65. They appear to follow the pinches and separate the shoots of ore from one another. The walls of these slides dip to the northwest from 40° to 75° , or at right angles to plane of the dip of the ore beds; and they are smooth, in places ribbed and grooved. The amount of dislocation in the upper slide is 35 feet, in the second 5 feet, and in the lowest 14 feet, completely separating the ore on the two sides. It is to be observed that the greatest break is at the top where the angle is steep. And in each case the ore bed has slipped down. The superintendent, Capt. Jos. Richards, says that when he meets with one of these cross-slide walls, his practice is to sink down vertically through them to the ore.

The walls of the mine are generally clean and firm. The irregularities in the size of the ore-bed appear to be due rather to rolls in the foot wall, and particularly near the cross slides they flatten and approach the opposite or hanging wall. Very little timbering is necessary. The quantity of mine water near the surface is large, but the lower stopes are comparatively dry. Three pumps, respectively, 14-inch, 12-inch and 8-inch cylinders, are in use. The ore is raised in buckets from foot of slope; in the mine, cars bring it out of the several levels to the slope. It is rich, averaging nearly 70 per cent. of metallic iron and free from pyrite. The phosphorus is in excess of Bessemer requirements. In the pinches the ore often shows a prismatic structure with its planes, at right angles to the walls, or somewhat analogous to the trap-rock of some narrow dikes. The product

of this mine has been for many years steadily large and has found a ready market on account of its excellence.

Geology of New Jersey, 1868, pp. 578-582.

Annual Report, 1873, p. 44.

" 1879, p. 55.

BAKER MINE, near Mount Pleasant, Morris county.

Geology of New Jersey, 1868, pp. 582-583.

Annual Report, 1873, pp. 44-45.

" 1879, p. 55.

RICHARD MINE, Mount Pleasant, Morris county.

The Richard mine occupies 2,700 feet of the ore range, extending from the Baker, on the southwest, to the Allen, at the northeast. The southeast *vein* is opened throughout, except near the Allen mine line. Beginning at the southwest, slope No. 1 runs down on the foot wall, about 260 feet. It opens the shoot which entered the property from the Baker mine. No. 7 shaft, near No. 1 slope, but to northeast of it, is not now used. No. 2 shaft is 388 feet deep, vertically, running on the foot wall after going about 150 feet straight down from the surface. Southwest of it 524 feet, there is an offset which has not been cut through, though the drifting from each side has worked up to it. The course of this fault is at right angles to that of the vein, and it is almost vertical, dipping, however, steeply to the southwest. Shaft No. 3, like No. 2, goes down vertically, and then follows on the foot wall, and has a vertical depth of 402 feet. It is not in use at present, as water and ore are raised through No. 2 shaft. Northeast of this shaft 461 feet, and 156 feet from the Allen mine, another offset is met with; it too is very nearly vertical. But no ore has been found beyond it corresponding to this vein, although much drifting has been done in search of it. The shoot and pinch structure is shown in this vein in its "bunches" of ore and "squeezes." And they pitch to the northeast. Between shafts No. 2 and 3 there is a pinch which was cut through for 300 feet by a horizontal drift. And for all this distance the average thickness of the ore did not exceed twelve inches. Judging from the mine map, this pinch pitches gently to the northeast. In places, this vein has been as much as 20 feet wide. Occasionally, there is some rock in the vein. According to the superintendent, Mr. Jenkins, the size of the vein is altered by

the "rolls" or inequalities which come in on both the foot and hanging walls.

On the north Baker vein, a new slope near the Baker line and south of Mr. Jenkins' residence, was put down several years ago to a depth of 150 feet. The vein opened in it is 10 feet wide. But it has not been worked, as enough ore was had elsewhere and obtained more cheaply.

The unwatering is by pumps in slope No. 1 and shaft No. 2. The ore is raised in cars in the slope, and in buckets in shafts Nos. 2 and 3. Compressed air and machine drills are in use. The ore is rich. It is all smelted at the company's furnaces at Hokendauqua.

Northwest of the vein now worked, and 200 feet from it, there is a parallel vein which is known as the Powell vein. It was worked, previous to the panic of 1873, to a depth of 500 feet in one slope (measured on foot wall of shoot). There is another, but small vein, between the Powell and the southeast vein. Beyond the former there are two other veins, both of which are small and are not much opened.

This mine is the property of the Thomas Iron Company, and is worked by that company. Its history is certainly one of prosperity and of successful management. Its annual output is large.

Geology of New Jersey, 1873, p. 588.

Annual Report, 1873, p. 45.

" 1879, p. 55.

ALLEN MINE, Rockaway township, Morris county.

This mine is one of the properties of the New Jersey Iron Mining Company. It is worked under a lease to the Andover Iron Company.

The exact relation of the veins opened on this property to the Baker and Powell veins, which are so well opened by the Richard mine, is not known. It has been assumed that the Allen workings were on the Powell, or northwest vein. But the tunnel into the hill, and subsequent borings with the diamond drill, seem to indicate that they are on the main southeast or Baker, or the main Richard mine vein. The main tunnel runs northwest into the hill, a distance of 600 feet, and strikes the ore at a depth of 130 feet below its outcrop. In this tunnel two small veins of ore were encountered—one near its entrance, and the other about 100 feet from the main mine vein. They were not of size for working profitably. From the end of the tunnel, or from the main vein, a drift was carried into the rock 385 feet, and then a boring 100 feet further, thereby cutting across nearly

500 feet additional of strata on the foot-wall side of the ore, but without discovering any more ore. Then, from the main vein, to southwest of the tunnel, a bore-hole was put in 600 feet in a southeast direction without encountering any ore. These drifts and borings appear to show that there is an offset between the Allen and the Richard mines, assuming the vein to be one. From the large size of the Richard mine shoot of ore, up to the offset, near the Allen line, it seems reasonable to believe that the ore will yet be found beyond it of like dimensions. It is possible that the Richard mine shoot pitches down to northeast deeper than any of the stopes or drifts of the Allen mine. And there may be a wide pinch between the shoots of the two mines which the deeper workings of the Allen are now in, and through which they have not gone. The explorations at this mine show the hopefulness and energy of the owners and lessees in searches for additional shoots of ore. And the results obtained, though not encouraging, are valuable contributions to our knowledge of ore-bodies and suggestive of other points for exploration. They certainly deserve success. Very little work is being done at the mine at present.

Geology of New Jersey, 1868, pp. 583-587.

Annual Report, 1873, p. 45.

" 1879, pp. 55-56.

TEABO MINE, Rockaway township, Morris county.

The Teabo mine is on Teabo hill, southwest of Mount Hope. It is owned and worked by the Glendon Iron Company. The Brennan vein, which was opened years ago, near the Mount Hope line, is not worked. The Teabo mine is opened by four shafts, of which Nos. 3 and 4, to the southwest, are now in use, and both open one continuous shoot of ore. No. 4, the newer shaft, is vertical for 100 feet, then descends on the foot wall to a depth of near 500 feet. The old workings on this vein have been abandoned for many years. The breadth of ore varies somewhat, owing to bunches and pinches, or squeezes, in it, but averages well, and the annual product of the mine keeps steadily large. The ore is carted to the Mount Hope Mineral Railroad line, to the southeast of the mine, as the side hill is too steep for an easy grade to the shafts from that road. The ore is used at the company's furnaces, at Glendon, Pa.

Geology of New Jersey, 1868, pp. 587-588.

Annual Report, 1873, p. 45.

" 1879, p. 56.

MOUNT HOPE MINES, Mount Hope, Morris county.

The mines of the Mount Hope Mining Company (Lackawanna Iron and Coal Company, practically,) are in Teabo hill, at the southwest; in Mount Hope; and in Hickory hill, at the northeast. The property of the company extends to the northeast, beyond the Hickory Hill mines.

At present the principal work is in the Mount Hope mines, and is confined to the Platt mine, on the Taylor or Jugular *vein*, and the Side Hill and Teabo *veins*. The Platt mine has reached a depth of 200 feet below the tunnel-level. The shoots are large and pitch to the northeast. The ore from the lower stopes is richer than that of the stopes above the level of the tunnel, and the mining is directed to the former, the upper and lean portion of the vein being left for the present. Hornblende appears to characterize the ore of this vein as the foreign constituent associated with the magnetite. The ore is raised in cars, which run on a skip track to the tunnel. The volume of mine water is not large.

The Teabo and Side Hill *veins* are opened east of the Taylor vein, and on the eastern slope of Mount Hope. The former maintains a regular northeast strike, but the Side Hill appears to bend to east, and at the new shaft they are several hundred feet apart, as traced on the surface by openings and by the attraction. A few hundred feet further northeast, the attraction is lost, and is not recovered until past the Hickory hill offset. Descending, these *veins* approach one another, due to the northwest dip of the Side Hill *vein* in a part of its course. In places the walls are vertical, and in the big shoot of the higher levels it has been supposed that the *veins* were together. In the sink the ore breadth of 12 feet does not exhibit the two characteristic varieties of ore which were noticed above, and it seems as if the Side Hill *vein* would yet be found to the east, or in the hanging wall. The ore of the Teabo *vein* is close-grained and breaks into cubical or rectangular masses, whereas the Side Hill ore is coarse-granular, but not a shot-like mass or aggregate. The reversed dip and the approach of the two veins, and their apparent union in the big shoot, make one of the most unusual modes of occurrence, and were it not for the dissimilar nature of the ore, they might be considered as the two sides of a sharp synclinal fold. The existence of the Side Hill *vein* to the east of the present sink will seem, however, to indicate the separation and continuance of two distinct ore-beds, but with varying dips.

The mine in the sink has reached a vertical depth of 420 feet, or 330 feet below the tunnel. The ore at the bottom is rich, and the breadth is 12 feet. In the shoot above, it was 15 feet. In places it has pinched to five feet.

On Hickory hill the mines are idle, with the exception of the new mine to the northeast a half mile, on the top of the ridge. This mine is down 300 feet, and the *vein* is six feet wide, but very uneven and "bunchy" in shape. These bunches, or shoots, pitch to the northeast. The dip is steep to southeast. The ore is rich and coarse-granular in structure. This mine opens the Brennan *vein*. A large stock of ore is at the mine, as there is no railroad to it. A gravity line is possible down to the Mount Hope Branch.

About a quarter of a mile north of this point, an old shaft, now fallen in, is on the Side Hill *vein*. Other attractions to west are probably in the Jugular range. The identification of all the Mount Hope *veins* or ore beds throughout the whole length of Hickory hill will be awaited with interest, as indicating a remarkable belt of ore or series of *veins*.

At the southwest the company is re-opening the Elizabeth drift in the north side of Teabo hill. Searches are also being made for the south extension of the Taylor or Jugular *vein* in that hill.

The ores of these mines are mostly sold to furnace companies in Pennsylvania. The annual output is still large, and the total product is probably greater than that of any other mine or group of mines in the State.* And the capacity seems as unlimited as at any time in all their history.

Geology of New Jersey, 1868, pp. 588-595.

Annual Report, 1873, pp. 45-46.

" 1879, p. 56.

" 1880, p. 107.

DENMARK MINE, near Denmark, Morris county.

Geology of New Jersey, 1868, p. 597.

GREENVILLE MINE, Greenville, Rockaway township, Morris county.

Annual Report, 1873, p. 48.

" 1879, p. 58.

These localities have not been worked during the year. They are three to four miles from railway stations.

* In 1880 the aggregate product of these mines was estimated at 1,000,000 tons.

CHESTER IRON COMPANY'S MINES, near Denmark, Morris county.

Six openings have been made on lands of this company at the foot of the Copperas mountain range and north of Denmark. The explorations have not led to active working in consequence of the length of cartage to railway points.

Annual Report, 1873, p. 48.

" 1879, p. 58.

PARDEE MINE, Rockaway township, Morris county.

Annual Report, 1873, p. 48, (Pardee & Canfield's Mine.)

WINTER SHAFT, Rockaway township, Morris county.**DAVENPORT MINE, Rockaway township, Morris county.**

These two mines are now under lease to the Mutual Iron Company. The Davenport mine proper has four shafts in a distance of 250 feet on the line of the vein, from the road southwest, and near the foot of the Copperas mountain. The deepest of them is 80 feet deep. The whole length opened on the vein is about 350 feet, and the ore has an average breadth of 10 to 12 feet. The shafts descend on the foot-wall to the southeast. The average dip is 40°. The ore resembles in general character that of the Green Pond mines, which adjoin this property on the northeast. The so-called Winter shaft is 400 yards south of the Davenport, and at the west border of the marsh. It was sunk about a year ago, and to a depth of 20 feet. The ore was 12 feet wide and rich, and coarse-crystalline in structure. It appears to carry less pyrite than the openings to the north. Another shaft is being put down nearer the foot of the mountain and 500 feet west of the Winter shaft. It is within a few yards of the open cut and workings of Messrs. Pardee & Canfield.

An extension of the Green Pond Mines Railroad to the Davenport shafts affords means of loading directly from them. The road is to be extended south to the Winter shaft, and a branch to the new west shaft near the old Pardee mine.

The further extension of this line southwest by Denmark and Middle Forge would tend to develop the ore properties along this range, and furnish an outlet for the ores in that direction.

Annual Report, 1880, pp. 122-123.

GREEN POND MINES, Rockaway township, Morris county.

These mines have been idle during the year.

Annual Report, 1873, pp. 48-49.

" 1874, pp. 23-25.

" 1879, pp. 58-60.

" 1880, p. 108.

HOWELL TRACT OPENINGS, Rockaway township, Morris county.**KITCHELL TRACT OPENINGS, Rockaway township, Morris county.**

Annual Report, 1879, p. 60.

" 1880, p. 108.

CHARLOTTEBURGH MINE, Charlotteburgh, Morris county.

This mine is now owned and worked by Cooper, Hewitt & Co. It has been in operation uninterruptedly since January, 1880, and has been under the superintendence of Edward George. The old and, for the present, abandoned holes are located near the pond, and to the west of the present shafts. As described by Mr. George, there appear to be five parallel shoots of ore within a breadth of 200 feet, from northwest to southeast, and all strike and pitch to the northeast. Three shoots are at present worked. The southwest shaft, on the principal range or shoot, strikes the bottom rock at a depth of 100 feet. The ore was 40 feet wide, but narrowed going northeast to a breadth of 12 feet. The dip is steep to the east-southeast. The pitch is flat, and nearer the pond the ore was in places within three feet of the surface. The shoot next southeast, on the hanging-wall side of this one, is not so large, though it is worked. The greatest depth of the mine is 200 feet. At the northeast the ore pitches under the pond. The ore at the top, and for four or five feet down, is red; below it is hard, blue, and contains some pyrite. On the foot-wall side of the easternmost opening the ore is very rich and crystalline in structure. The hoisting is done by a small steam engine, and the pumping by small steam pumps, as the quantity of mine water is not large. About 5,000 tons are stocked and now on the bank. A switch from the Green Pond Mine Railroad runs to the mine, and the ore is loaded direct from the mine upon the freight cars.

Geology of New Jersey, 1868, p. 596.

Annual Report, 1873, p. 49.

" 1879, p. 60.

" 1880, p. 108.

SWEDES MINE, Rockaway township, Morris county.

Geology of New Jersey, 1868, pp. 551-554.

Annual Report, 1873, pp. 46-47.

" 1879, p. 56.

SIGLER MINE, Rockaway township, Morris county.**WHITE MEADOW MINE**, Rockaway township, Morris county.**GIBB MINE**, Rockaway township, Morris county.**BEACH MINE**, Rockaway township, Morris county.

For notes of these four mines, see

Geology of New Jersey, 1868, pp. 559-560.

Annual Report, 1873, pp. 46-47.

" 1879, p. 56.

HIBERNIA MINES, Hibernia, Morris county.

Three companies work this long and continuous ore bed or *vein* of ore. The Andover Iron Company has the Lower Wood Mine, at the southwest; the Glendon Iron Company works the Glendon, Scott, DeCamp and Upper Wood lots, and, at the northeast, the Willis is leased to the Bethlehem Iron Company. Of these several mine lots, the Lower Wood, the Upper Wood and the Willis lots are owned by the New Jersey Iron Mining Company; the Glendon lot by the Glendon Iron Company, and the Scott and DeCamp lots by other parties.

The whole line is worked, excepting the Willis mine. The Bethlehem Company has suspended work for a time.

The tunnel which was driven in on the line of the *vein* several years ago is occupied by the Hibernia Underground Railroad. This road runs as far as the Bethlehem Company's mine, and affords an outlet for the ores of all the individual mine lots. Each of the three companies has its switch and dump near the mouth of the tunnel and on the south end of the hill. There the ores are transferred to the Hibernia Mine Railroad. The tunnel also serves as a water-way, and the water pumped to this level then flows out through it. The motive power for hoisting and pumping of the Glendon and of the Bethlehem Companies remain as first placed, on the top of the hill. But no ore or water is hoisted above the tunnel. The Andover Company has its engines outside and near the mouth of the tunnel. The latter company intends to put in a skip track to run down obliquely

on the foot wall, and so increase its capacity for raising ore. The three mines are separated below the tunnel by solid pillars of ore. Above it the mines are necessarily somewhat connected. The yearly product of these mines (or mine, as it is in fact one solid ore bed,) continues large, amounting, in 1883, to 94,519 tons.

Among the more noticeable structural features, the following may here be mentioned. In the Upper Wood mine and in shafts Nos. 6 and 7, the dip of the ore bed has continued, until near the present depth, to be steep to the northwest. But recently the direction has changed and the descent is now to the southeast. Elsewhere on the line the usual southeast dip has been the only direction observed.

In the Lower Wood Mine there are two marked offsets or faults. In both of them the course of the fault is nearly at right angles to the strike of the ore, and the plane dips nearly vertically to the south-southwest. The displacement is to the southeast or hanging wall in each one. In one the ore is separated entirely, as the displacement exceeds slightly the breadth of the ore, which here is about 10 feet. At the northeast fault the dislocation is five feet only. The ore bed preserves its characteristic features on both sides of the offset in each case.

In this mine the foot wall shows more irregularities or rolls than the hanging wall. And in places it appears to pinch the ore by the slabs or layers of rock which come in on that side, replacing, as it were, the ore step by step. The hanging wall is generally firm, excepting a thin stratum of rock, which appears in places and comes off with the ore. Owing to the pinches the ore ranges from 2 to 20 feet in thickness. And these thicker ore bodies or shoots pitch to the northeast.

The deepest workings in the Lower Wood mine have resolved what were supposed to be two *veins* into one, and proved the rock to be a *horse* lying in the ore.

The bedded structure or stratification of the ore is finely exhibited in this mine, both in the deeper stopes and in the open cuts on the hill. And the two *veins* are to be seen in the open cuts on the hill.

The gneiss outcrops, on the hill near the open cuts, show the micaeous schistose gneiss included in the gray feldspathic variety, somewhat as the magnetic iron ore beds are in places enclosed by the same gray gneiss.

Geology of New Jersey, 1868, pp. 561-564.

Annual Report, 1873, p. 47.

" 1879, pp. 56-57.

" 1880, p. 108.

BEACH GLEN MINES, Rockaway township, Morris county.

The Beach Glen mines are the property of the J. Cooper Lord estate, and under the management of Gen. J. S. Schultze, of Boonton.

Of the two *veins*, only the west one is now worked. From the southwest foot of the hill, a tunnel, 1,600 feet long, runs in a north-east direction into the *vein* and gives an easy outlet for ore and water to a depth of 125 feet at the heading. Present workings about 70 feet deeper. The ore obtained from this *vein* is not so lean as that of the other and east *vein*. The latter is remarkable for its percentage of mica. The ore is sold for Bessemer pig manufacture, and the product is 800 tons monthly.

Geology of New Jersey, 1868, pp. 554-556.
Annual Report, 1879, p. 57.

MERIDEN MINE, Meriden, Morris county.**RIGHTER MINE**, near Meriden, Morris county.**COBB MINE**, end of Splitrock pond, Morris county.

These mines have been idle for a year or more.

Annual Report, 1873, p. 47.
" 1879, p. 57.
" 1880, p. 108.
Geology of New Jersey, 1868, p. 556, (Meriden mine.)

SPLITROCK POND MINE, at head of Splitrock pond, Morris county.

It is reported that this mine has been re-opened recently, but nothing further is known of it. It has been mentioned in the

Annual Report, 1873, pp. 47-48.
" 1874, p. 23.
" 1879, pp. 57-58.
" 1880, p. 108.

WOOD MINE, north of Splitrock pond, Rockaway township, Morris county.

The Pequannock Iron Company has recently re-opened a locality first developed by Wm. S. DeCamp several years ago, and located about two miles south of Charlotteburgh, and at the east side of the road leading to Splitrock. A great deal of work has already been done, and some ore is said to have been shipped. The locality was visited

in 1874, and referred to in the annual report for that year. (See page 23.) It was not visited the last season.

BOTTS' MINE, Rockaway township, Morris county.

ROCKAWAY VALLEY MINE, Rockaway township, Morris county.

DECKER FARM OPENING, Rockaway township, Morris county.

Excepting a little work done at one shaft of the Rockaway Valley mine during the summer of 1883 by Mr. Ripley, of Newark, these mines have been idle all the year. The buildings and machinery have been removed from the Rockaway Valley shafts, which were leased by A. Pardee & Co., and the mine abandoned.

Annual Report, 1873, pp. 49-51.

" 1879, p. 60.

" 1880, p. 109.

GOULD MINE, Rockaway township, Morris county.

PIKE'S PEAK MINE (Stony Brook mine), Rockaway township, Morris county.

RIGHTER LOT OPENING, Rockaway township, Morris county.

Geology of New Jersey, 1868, p. 556, (Stony Brook mine.)

Annual Report, 1873, p. 51.

" 1876, pp. 54-55, (Stony Brook mine.)

" 1879, pp. 60-61.

" 1880, p. 109.

VREELAND MINE, near Charlotteburgh, Passaic county.

Annual Report, 1879, p. 61.

WANAQUE MINES, Pompton township, Passaic county.

Geology of New Jersey, 1868, pp. 545-546, (Wynokie.)

Annual Report, 1873, p. 52, (Wynokie.)

TELLINGTON MINE, Pompton township, Passaic county.

RHEINSMITH MINE, Pompton township, Passaic county.

MONKS MINE, Pompton township, Passaic county.

Annual Report, 1873, p. 52, (Monks mine.)

" 1874, pp. 25-26, (Tellington mine, Rheinsmith farm.)

" 1879, p. 61.

WRIGHTNEOUR MINE, west of Monks station, Passaic county.

Annual Report, 1881, p. 36.

BOARD MINE, near Monks station, Pompton township, Passaic county.

The Pardee lease of this property was given up several years ago. The property is now under the management of Daniel A. Wheeler. In the spring of 1882, some further work in exploring was done, and near the old openings Mr. Wheeler found the ore near the surface from three to eight feet under earth, and in apparent strata of considerable thickness. The trial openings are a few yards north of the main mine and open cut. The beds dip about 30° easterly. And the ore is rather lean, consisting of quartz in fine granular mixture, with magnetite; very little feldspar or hornblende is seen in the mass, nor any apatite or pyrite. There is strong attraction about the old open cut, and for 150 feet east of it, but not traceable to north or south. In a shaft north-northwest of the open cut, a few yards, a bed of rich ore, about a foot thick, and associated with lean ore, was met with and followed to a depth of 25 feet. This ore must dip under the beds opened in the old mine. A few rods northeast of the mine, and running up the hill side to the Ringwood property, there is a strong positive attraction. Two pits were sunk on this belt of attraction by John Webb, when he had charge of the property under the lease to Mr. A. Pardee.

A letter, recently received from Mr. Wheeler, reports that the mine has been leased by Joseph L. Cunningham, of Ringwood, who has already commenced the work of raising and shipping ore. An engine is to be set up and all the machinery necessary to run the mine. The outlook is said to be promising, and the ore appears to be richer than the surface openings indicated. The development of the locality is awaited with interest, as the surface indications and the attractions give promise of ore beds of considerable extent.

Annual Report, 1873, p. 52.

" 1879, p. 61.

RINGWOOD MINES, Ringwood, Passaic county.

Of the Ringwood group of mines, the new Miller, Peters and new Peters, are at work. The new Miller mine has been actively worked for the past two years, and has yielded a large amount of rich ore.

The slope follows the shoot, descending on the foot wall at an angle of 55° . The foot wall dips at an angle of 60° toward the southeast. The ore comes off clean from it. On the hanging-wall side the rock carries some magnetite. The shoot, to a depth of 150 feet, was large, having a horizontal length, from the bottom rock at the southwest, to the cap rock at the northeast, of 300 feet, and an average breadth of 20 feet. At that depth a pinch was met with, and the ore breadth was reduced to five feet. The ore is fine grained and rich.

The Peters and new Peters mines are in two parallel shoots. The southeastern shoot has been followed down 400 feet, or to a vertical depth of 240 feet, the pitch being to the northeast. The form of this shoot is rather remarkable for its great thickness, as compared with its length. The horizontal section shows a length of 60 feet, and a breadth of 30 feet. The walls dip 40° to the southeast. The ore is rich and fine grained.

The mine on the northwest shoot is 200 feet deep, also measured on the angle of pitch, which is to the northeast. In shape it is more nearly a square, measuring 20 to 30 feet on a side. The dip of the strata here is steeper than in the other shoot, and is nearly vertical, to southeast. They appear to be approaching one another, and near the bottom of mine, a horizontal drift 50 feet long, connects the mines. In working the Peters mines, about one-third of the ore has to be left for pillars to support the roof and cap rock. But in none of these mines is there need of timbering, excepting in the construction of slopes.

The mines on this property appear to prove the existence of well-defined shoots of ore, which vary somewhat in shape. Thus, the Cannon shoot was for a long distance of greater breadth than height, or a flattened cylinder of ore. At a depth of 400 feet it still retained a breadth (from foot to hanging) of 50 feet. The Hard mine, also, was followed to a depth of 400 feet, when the shoot gave out, though in this mine the walls were not so clean or well marked as in the Cannon. The pitch in all of them is rather steeper than the average angle, and to the northeast in all cases. There appears to have been a greater compression of the ore into nearly vertical shoots, which are much like the so-called "ore chimneys" of the west. Instead of following on the line of strike in a more nearly horizontal direction, the work of mining has to proceed at a steep angle downwards. The pinches may be thinner, or the ore may be thinner, or the ore may be cut out entirely between the shoots. Thus far the mining and explor-

ations have not followed the pinches far enough to test the extent, nor to prove that there are not other bodies of ore beyond them in the line of the pitch. That the ore should be concentrated in these thick shoots, comparatively near the surface, and is not to be found going down much below the usual mine depth, is contrary to experience in the iron mines in other parts of the State.

The Ringwood ore deposits lie in feldspathic gneisses, generally; but at the Keeler, the walls are of hornblendic or syenitic gneiss. At the eastern foot of Hope mountain, both varieties crop out, in irregularly alternating and thin layers. The gray variety is marked by the presence of garnet as a constituent mineral, making a characteristic garnetiferous gneiss. It is also noteworthy that the ore ranges are confined to the eastern slope of the Whaleback-Hope mountain range. The mines are worked by the owners of this tract, Cooper, Hewitt & Co., and the ore is sold to different furnace companies.

Geology of New Jersey, 1868, pp. 546-550.

Annual Report, 1873, pp. 52-54.

" 1880, p. 109.

MUSCONETCONG BELT.

HAGER MINE, Holland township, Hunterdon county.

DUCKWORTH OPENINGS, Holland township, Hunterdon county.

BLOOM FARM, Holland township, Hunterdon county.

MARTIN FARM, Alexandria township, Hunterdon county.

None of these localities have been worked during the year. For previous notices of them see—

Annual Report, 1875, p. 85, (Bloom.)

" 1879, p. 62-63.

" 1880, p. 109.

PETTY FARM, Bethlehem township, Hunterdon county.

WRIGHT FARM, Bethlehem township, Hunterdon county.

CASE FARM, Bethlehem township, Hunterdon county.

These three localities also are idle. For descriptions, see

Annual Report, 1880, p. 123.

CHURCH OR VAN SYCKLE MINE, Bethlehem township, Hunterdon county.

This old iron ore mine has not been worked in several years.

Geology of New Jersey, 1868, p. 616.

Annual Report, 1873, p. 55.

" 1879, p. 65.

TURKEY HILL OR WEST END MINES, Bethlehem township, Hunterdon county.

These mines have been steadily worked during the year by their owners, the West End Iron Company, and under the management of G. M. Miller, of this company. The deeper workings are reported to be down over 200 feet. The ore is suited to Bessemer pig, and is shipped to Scranton, Pa. The same company works the—

SWAYZE MINE, near Valley Station, Hunterdon county.

Here a wire-rope tramway is in successful operation, transporting ore from the mine to the C. R. R. line near Valley Station, a descent of 518 feet in three-quarters of a mile. This, also, is a Bessemer ore.

The shipments from the mines during the year 1883 amounted to 16,000 tons. Previous notes of these Swayze and West End mines are in the—

Annual Report, 1874, p. 27, (Broderick and Harris Mines.)

" 1879, pp. 63-64.

" 1880, pp. 109-110.

ALPAUGH FARM, Bethlehem township, Hunterdon county.

WILDCAT MINE, Bethlehem township, Hunterdon county.

RODENBAUGH MINE, Bethlehem township, Hunterdon county.

References for these three localities in

Annual Report, 1879, p. 65.

" 1880, p. 110.

ASBURY MINE, Bethlehem township, Hunterdon county.

Geology of New Jersey, 1868, p. 617.

Annual Report, 1879, pp. 65-66.

" 1880, p. 110.

MILLER FARM, Bethlehem township, Hunterdon county.

MABERRY PLACE, Bethlehem township, Hunterdon county.

Annual Report, 1873, p. 56.

" 1879, p. 66.

" 1880, pp. 110 and 124.

BANGHART'S MINE, Lebanon township, Hunterdon county.

Geology of New Jersey, 1868, p. 617.

Annual Report, 1879, p. 66.

EVELAND MINE, Glen Gardner, Hunterdon county.

Annual Report, 1880, pp. 110 and 124.

TERRABERRY MINE, White Hall, Hunterdon county.

Annual Report, 1879, p. 66.

ALVAH GRAY OR SAND FLATS MINE, White Hall, Hunterdon county.

Annual Report, 1873, p. 56, (Fritts Farm.)

" 1879, p. 66.

" 1880, p. 124.

WHITE HALL (FRITTS FARM), White Hall, Hunterdon county.**CASTNER FARM, Lebanon Township, Hunterdon county.**

Annual Report, 1873, p. 56.

" 1879, p. 66.

MATTISON OPENING, Andersontown, Hunterdon county.

Annual Report, 1880, p. 124.

HUNT OR PIDCOCK MINE, Lebanon township, Hunterdon county.

Annual Report, 1873, p. 58.

" 1879, p. 66.

" 1880, p. 111.

SHARP'S MINE, Pleasant Grove, Schooley's Mountain, Morris county.**HANN MINE, Pleasant Grove, Schooley's Mountain, Morris county.**

Notes of Sharp's and Hann mines in

Annual Report, 1873, pp. 56-57.

" 1879, pp. 66-67.

" 1880, p. 111.

DERRENBERGER FARM, Schooley's Mountain, Morris county.

This locality, recently opened, is south of "Belmont Hall," and on the adjoining property known as the farm of the late John Derrenberger, but now owned by John P. Sharp. The ore near the surface was a rich brown granular magnetite. Hard blue ore, more or less sulphurous, was reached at a depth of 30 feet. The *vein* is tolerably well defined and is from four to five feet wide. The locality promises to be a good mine. The ore is used at the Chester furnace.

STOUTENBURGH MINE, Schooley's Mountain, Morris county.

A notice of this mine appeared in the Report for 1879. In that year, the owner, Mr. Stoutenburgh, reported an output of something over 2,000 tons. Since March, 1880, the property has been held under a lease by Joseph Wharton, and little work is reported, excepting the sinking of shaft on the Upper vein 50 feet deeper than it was before. A new line of attraction has been discovered running over a belt of *float ore*, in a northeast direction from the old or first shaft.

Annual Report, 1878, pp. 57-58.

" 1879, pp. 67-68.

" 1880, p. 111.

FISHER, or BEATTYSTOWN MINE, Schooley's Mountain, Morris county.

Geology of New Jersey, 1868, p. 618.

Annual Report, 1879, p. 68.

MARSH'S MINE, Schooley's Mountain, Morris county.

The Thomas Iron Company did some exploring work on this property of Wm. W. Marsh, about a year ago, and opened a *vein*, five feet wide and upwards, of hard, siliceous ore yielding on an average 45 to 50 per cent. of metallic iron. It was followed to a depth of 50 feet. The attraction and indications generally point to a large amount of ore as probably underlying the property. The depressed condition of the iron industry paralyzes all exploring work.

Geology of New Jersey, 1868, pp. 618-619.

Annual Report, 1879, pp. 68-69.

DICKINSON MINE, Schooley's Mountain, Morris county.**HUNT FARM, Schooley's Mountain, Morris county.**

LAKE FARM, Schooley's Mountain, Morris county.

Geology of New Jersey, 1868, pp. 619-620, (Dickinson mine.)

Annual Report, 1879, p. 69.

NAUGHRIGHT MINE, near Naughtrightville, Morris county.

Mr. Richmond, of Philadelphia, leased this mine of the owner, Theodore Naughtright, in 1883, and did a little work towards re-opening it and then suspended operations. It is now idle.

Annual Report, 1873, pp. 58-59.

" 1878, pp. 99-100.

" 1879, p. 69.

" 1880, p. 111.

SHARP FARM, Schooley's Mountain, Washington township, Morris county.**RARICK FARM, Schooley's Mountain, Washington township, Morris county.****HOPLER FARM, Schooley's Mountain, Washington township, Morris county.**

For notes of Sharp's, Rarick and Hopler, see

Annual Report, 1873, p. 59.

" 1879, p. 69.

POOLE PLACE, near Draketown, Schooley's Mountain, Morris county.

Annual Report, 1880, p. 112.

SHOUSE TUNNEL, east of Hackettstown, Morris county.**CRAMER MINE, east of Hackettstown, Morris county.**

Annual Report, 1877, p. 49.

" 1879, p. 70.

APPLEGET FARM, Mount Olive township, Morris county.

Annual Report, 1880, p. 125.

SMITH'S MINE, Mount Olive township, Morris county.

Geology of New Jersey, 1868, pp. 620-621.

Annual Report, 1879, p. 70.

LAWRENCE MINE, Mount Olive township, Morris county.

MOUNT OLIVE MINE, Mount Olive, Morris county.

Geology of New Jersey, 1868, p. 601.

Annual Report, 1873, p. 59.

" 1879, pp. 70-71.

" 1880, p. 112.

DRAKE'S MINE, Mount Olive, Morris county.**OSBORN'S MINE, Mount Olive, Morris county.****HILT'S MINE, Mount Olive, Morris county.****CHURCH MINE, Mount Olive, Morris county.**

Geology of New Jersey, 1868, pp. 599-601.

Annual Report, 1873, p. 59.

" 1879, p. 71.

The only one of the mines upon Mount Olive which has been in operation during the year is the line of openings between Turkey brook, at the southwest, and Mount Olive, at the northeast. The New Jersey Iron Mining Company owns the greater part of the line; the lease is held by Messrs. Stickle, of Rockaway; Wm. E. George, of Dover, agent and manager. There are two principal working shafts about 100 yards apart; the deeper one going down 170 feet on the foot wall, at an angle of 45° toward the southeast. The working length on the vein is about 300 feet. The walls roll, forming shoots of ore which *pitch* toward the northeast, and *pinching* the vein in places, but nowhere cutting out entirely. The ore has measured as much as 27 feet in width, but does not average more than five or six feet. One principal fault throws the vein into the hanging wall, going northeast. The ore is rich, but contains some sulphur. Several thousands of tons of the ore are stocked at the mine, as demand has been dull. Bartley, two and a half miles southeast, is the nearest railroad station.

KING MINE, near Drakeville, Morris county.**HIGH LEDGE MINE, near Drakeville, Morris county.**

These mines are on the King property, a half mile northwest of Drakeville. Both of them are idle. The High Ledge mine is leased

to Joseph Wharton, of Philadelphia. It was worked for a time last spring. The King mine has been idle more than a year.

Annual Report, 1879, p. 71.

" 1880, pp. 124-125.

MARIOT'S MINE, near Shippenport, Morris county.

GOVE MINE, near Drakeville, Morris county.

This mine has not been in operation during the year. It was last worked by F. N. Gove, of Brooklyn. It was sold recently to close litigation. There are two shafts down about 400 feet. And there is said to be a thickness of seven feet of ore on the foot-wall side. The ore is very rich, but contains sulphur in scattering streaks of pyrite.

Annual Report, 1879, p. 71.

" 1880, p. 112.

BURT MINE, Drakeville, Morris county.

This locality was opened years ago by Wm. S. DeCamp and others. In the spring of 1882, it was re-opened by the Old Furnace Mining Company of New York, by whom it has been steadily worked since that time. Within a distance of a quarter of a mile, there are seven shafts on the vein, whose outcrop is on the steep hill side, about 70 feet above the meadow. The deepest of them is down about 80 feet, and is connected with shaft to northeast 100 feet away by underground drifts. The ore breadth in the shaft near the engine-house is 24 feet; but there are no proper walls. In the next shaft to northeast, it is 6 to 7 feet wide, at depth of 50 feet. The dip in the main shaft appears to be steep to the west-northwest, but a roll in the wall may account for this direction, as in all the other shafts the usual southeastern dip is observed. The ore is lean, and contains some pyrite. At time of visit, about 400 tons of ore had been shipped, and a much larger amount was at the mine. A road has been built to the Delaware, Lackawanna and Western railroad track, a quarter of a mile distant. The locality is convenient for shipment, and there seems to be an abundance of ore. Its leanness may, however, offset the advantages of convenience to railroad and size of vein.

SILVER SPRING MINE, Morris county.

A new locality, which was worked by Whitlock & Lewis, of Dover, for a short time. The ore is sulphurous. A considerable amount was mined, but not shipped.

DAVENPORT MINE, near Berkshire valley, Morris county.

Geology of New Jersey, 1868, p. 602.

LAKE VIEW MINE, Morris county.

This name is given to an old mine, which was re-opened in the autumn of 1882, by the present lessees, the Hopatcong Iron Company. The mine is about a quarter of a mile west-northwest of the Lake View House, and 100 yards from the shore of the lake. There are three shafts, which are 85, 84 and 60 feet deep, respectively. The length of the ore opened, from northeast to southwest, is 150 feet, and the three shafts are all connected by drifts. The dip is toward the southeast, and average thickness is about six feet, varying, however, somewhat, from point to point. The foot wall is clean, but on the hanging-wall side the ore is mixed with rock. Most of the ore is rich and carries little sulphur. Some, from near the hanging wall, contains feldspar. An open pit, at north of engine house, is the site of an older opening, made about twenty years ago. In it the strata stand vertically. Another old shaft is a few rods southwest of the present middle one. J. R. Rose, of Stanhope, is superintendent for the company. The ore is carted to the Ogden Mine Railroad, about one mile distant to the east, and is sent to Perryville, Penn.

NOLAND'S MINE, Lake Hopatcong, Morris county.

Geology of New Jersey, 1868, p. 603.

HURD MINE, Hurdstown, Morris county.

The Glendon Iron Company continues to work this mine as vigorously as ever, and the slope has reached a length of 2,100 feet, following the shoot of ore down to the northeast. The pitch remains about the same angle as in the upper part of the mine, and the walls dip almost vertically to the southeast. The height, from bottom rock to cap rock, measured vertically, is 65 to 70 feet; the breadth, from wall to wall, 30 feet. The walls are firm and clean. The practice is to drift in the ore horizontally until the cap is reached, then work down the stope to the bottom rock. No ore is seen in the latter. As the cap has to be arched for security, there may be some ore left in it. Thus far, however, there is no evidence of another and parallel shoot above this one. There is some rock in the form of flat *horses*, and thin layers which run out into the shoot from the same, all of which

have to be removed in mining. The track is straight and is laid upon the bottom rock. As the walls are so firm, no timbering is necessary, excepting what is used in the construction of the slope. The amount of water to be pumped is not large, when the great length is taken into account, and four hours' pumping raises the water of 24 hours' gathering. The ore is hoisted in cars, which carry two to two and a half tons at a time, and which are switched at the head of the slope to the particular track where the ore is to be dumped.

The ore continues to have the same general appearance which marked it years ago. Much of it is a rich, fine crystalline and shot-like mass; some of it is coarse crystalline, but equally rich. Some of it is sold for *fixing*. When visited, the mine was producing 700 tons weekly, and a large stock of ore was piled up about the mine mouth.

The side shoot, southeast of the old open cut, is not worked. It is peculiar in form, as it is 20 feet wide and only four or five feet high. It has been mined to the depth of 100 feet. The upper part of this mine and the southwest shoot, or, more properly, the displaced portions of this shoot to the southwest, and the fault, are exhibited in longitudinal section, on page 67.

It is noticeable here that in the ledges of gray gneiss on the hill, east of the mine, the pitch corresponding to that of the shoot in the mine, and the steep southeast dip, are plainly recognized.

The mine is owned by the Hurd estate, and is worked under lease from the heirs, by the Glendon Company. Nearly all of the ore is used at the company's furnaces, at Glendon, Pa.

Geology of New Jersey, 1868, pp. 606-610.

Annual Report, 1873, p. 65.

" 1879, p. 72.

LOWER WELDON MINE, Jefferson township, Morris county.

Annual Report, 1873, p. 65.

" 1879, p. 72.

WELDON MINE, Jefferson township, Morris county.

The last work here was done by the Weldon Mining Company several years ago. It has always been an interesting place, because of the two shoots of ore which pitch to the northeast at an average angle of 35°. A longitudinal vertical section, on page 72, exhibits them in their correct proportions as worked out at the time the mine survey was made. As followed below the depth thereon

represented, the shoots pinched so small as no longer to be profitably worked. They appeared to diverge slightly.

Geology of New Jersey, 1868, pp. 610-612.

Annual Report, 1873, p. 65.

" 1879, p. 72.

" 1880, p. 112.

DODGE MINE, Jefferson township, Morris county.

The Weldon Mining Company operated here until 1881, since which date no mining has been done. F. N. Gove, of Brooklyn, is reported to have found some remarkable magnetic attraction and to have begun searches for additional shoots of ore.

Geology of New Jersey, 1868, p. 614.

Annual Report, 1879, p. 72.

" 1880, p. 112.

FORD MINE, Jefferson township, Morris county.

The Ford mine is worked by A. Pardee & Co. for the supply of ore to the Musconetcong Iron Works. Both the Glendon and the Ford veins are being followed in the mining, which has reached a depth of 250 feet. The walls stand up almost vertical, dipping to southeast. At the bottom, in the southwestern part of the mine, the ore is pinched up to a foot in width on the hanging-wall side of the vein. There is no *cap-rock*. The veins are large and the *horse* of rock between them is diminishing in size at the northeast. And it may be discovered that they are parts of one large shoot at a greater depth.

Geology of New Jersey, 1868, pp. 614-616.

Annual Report, 1873, p. 66.

" 1879, p. 72.

" 1880, p. 113.

SCOFIELD MINE, Jefferson township, Morris county.

This mine continues to be worked by the Lehigh Crane Iron Company, David Jenkins, superintendent.

Geology of New Jersey, 1868, p. 615.

Annual Report, 1879, pp. 72-73.

" 1880, p. 113.

GOBLE MINE, Jefferson township, Morris county.

BOSS MINE, Jefferson township, Morris county.

FRASER MINE, Jefferson township, Morris county.

DUFFEE MINE, Jefferson township, Morris county.

SHONGUM MINE, Jefferson township, Morris county.

No reports of the working of any of these places have been received, and, so far as known, they have been idle for years.

Geology of New Jersey, 1868, pp. 612-614.

Annual Report, 1873, p. 62.

MINE NEAR WOODPORT, Morris county.

This locality is at the side of the Sparta turnpike, about a half mile northwest of Woodport. The vein is reported as being five to six feet wide, and the ore contains some sulphur. No work has been done in two years.

CLINE OPENINGS, Pohatcong mountain, Franklin township, Warren county.

SMITH OPENINGS, Pohatcong mountain, Franklin township, Warren county.

DEAN OPENINGS, Pohatcong mountain, Franklin township, Warren county.

Annual Report, 1879, p. 73.

CARTER MINE, near Stewartsville, Greenwich township, Warren county.

Annual Report, 1880, p. 125, ("Willever & Godfrey mine.")

CHAPIN AND LOMMASSON TUNNEL, near Oxford Furnace, Warren county.

Annual Report, 1873, p. 60.

LANNING MINE, near Oxford Furnace, Warren county.

The openings on the S. Lanning place are southeast of the Car-wheel and New mines of the Oxford Furnace property, and are near the top of the ridge. The place was worked two years by the Oxford Iron Company, and yielded about 12,000 tons of ore in that time. It was abandoned last season; and it has been idle since that lease expired. On the same property, but higher up on the hill, there is a belt of attraction where trenching and shafting, in search of the ore, have failed to find the bed or the cause of this magnetic disturbance.

It is one of the localities where the surface indications have not proved to be as good as they promised.

Annual Report, 1873, p. 60.

OXFORD FURNACE MINES, Oxford Furnace, Warren county.

Of the several mines of the Oxford Iron Company, only the Car-wheel and the Washington have been worked during the year. The production is maintained at very nearly a steady rate year by year, and the ore is all used at the furnaces of the company.

The Washington *vein* was surveyed by Wm. H. Scranton, and a map of the magnetic survey was printed in the Annual Report for 1879, page 96. It is important to note that the opening on this very regular line of attraction has discovered a very long and regular ore bed. And the ore is found to be less sulphurous as the workings get deeper. The average breadth of the ore is nine feet.

In structure the openings in the shoots of the Car Wheel and New mines show a very remarkable fold or bend in the course of the ore beds and the strike of the associated gneissic strata. The main shoots of these mines are parallel and close to one another, so that their workings are connected. Their course, or strike, is from northwest to southeast, but curving at each end so as to resume the normal northeast and southwest directions. At the northwest the *vein* curves around, and is thence traced, by continuous openings, into the Staley mine or *vein*. The curve at the southeast end of the main openings is also well defined, but it has not been traced as far in that direction. The dip in the mines is to the northeast, which corresponds with the southeast dip of the normal course at each extremity. Here there is a good illustration of a lateral fold or contortion in the rocks and the ore, produced, apparently, by a compressing force acting on a northeast and southwest line, so as to shorten the beds, and, also, *bunching* the ore in thick shoots where the folding occurred. The Lanning mine is thought to be on the extension of the range to the southwest. The other mines of this company, and on this tract, are also supposed to form parts of other, exterior folds; but they need to be more carefully examined to determine this position. And the proofs of folding on a large scale must here be obtained from careful surveys. The causes have been referred to on pages 72-75.

Geology of New Jersey, 1868, pp. 637-640.

Annual Report, 1873, p. 61.

" 1879, pp. 74, 96.

" 1880, p. 113.

CREAGER MINE, near Port Murray, Warren county.

MITCHELL MINE, near Port Murray, Warren county.

JOHNSON SHAFTS, near Port Murray, Warren county.

STEPHENSON MINE, near Port Murray, Warren county.

Notes of Port Murray mines in

Annual Report, 1873, pp. 61-62.

“ 1879, p. 75.

“ 1880, p. 113.

BALD PATE MINE, north of Port Murray, Mansfield township, Warren county.

SHAFER, or WELCH PLACE, north of Port Murray, Mansfield township, Warren county.

EGBERT CHURCH MINE, north of Port Murray, Mansfield township, Warren county.

Geology of New Jersey, 1868, p. 624, (“Bald Pate mine.”)

Annual Report, 1873, p. 62.

“ 1879, pp 75-76.

“ 1880, p. 113.

SEARLE MINE, Independence township, Warren county.

Geology of New Jersey, 1868, p. 624.

BARKER, or BULGIN MINE, near Vienna, Warren county.

BUCK'S HILL OPENINGS, near Hackettstown, Warren county.

DAY MINE, near Hackettstown, Warren county.

FRACE FARM, north of Hackettstown, Warren county.

YOUNG FARM, north of Hackettstown, Warren county.

PYLE FARM, north of Hackettstown, Warren county.

AXFORD FARM, north of Hackettstown, Warren county.

BRYANT MINE, near Warrentown, Warren county.

EXCELSIOR MINE, Allamuchy township, Warren county.

EUREKA MINE, Allamuchy township, Warren county.

TUNISON PLACE, Allamuchy township, Warren county.

WINTERMUTE FARM, Allamuchy township, Warren county.

HAGGETY'S MINE, Allamuchy township, Warren county.

A long list of localities, scarcely any of which have been explored and opened sufficiently to deserve the designation of *mines*; and, so far as known, all of them are idle at present. In a number of them the ores are lean, properly magnetite in rock, both stratified and massive; in some of them the veins are too narrow for profitable working. In the few out of the whole number which have produced ore in quantity, the distance from transportation would make the ore cost too much when the markets are so depressed as during the past year.

Annual Report, 1873, pp. 63-64.

" 1876, p. 52, (Haggerty's mine.)

" 1879, p. 76, (Haggerty's mine.)

" 1880, p. 127, (Wintermute's farm.)

BROOKFIELD, or WATERLOO MINE, near Waterloo, in Warren county.

Geology of New Jersey, 1868, pp. 626-628.

Annual Report, 1873, pp. 64-65.

" 1879, p. 76.

FRENCH'S PLACE, Byram township, Sussex county.

Annual Report, 1873, pp. 66-67.

" 1879, p. 77.

SMITH, or CASCADE MINE, Byram township, Sussex county.

A little work was done near the old shafts of this mine and west of them, on the hill side. The dip of the outcropping strata and of the ore beds is 35° - 45° to the east. The strike in all this vicinity is to the north, or a few degrees east of north. There is much dark colored, hornblendic rock associated with the ore, both on this hill and in the old openings. For notes describing the mine, see

Annual Report, 1873, p. 66.

" 1879, p. 77.

ALLIS OPENINGS, Byram township, Sussex county.

Annual Report, 1873, p. 66.

" 1879, p. 77.

HUDE, or STANHOPE MINE, Stanhope, Sussex county.

The Hude mine has been temporarily closed. It was last worked by John M. D. Barnes, of Ironia, for A. Pardee & Co. No ore was raised during the year.

Geology of New Jersey, 1868, pp. 622-623.

Annual Report, 1873, p. 67.

" 1879, pp. 77-78.

" 1880, p. 114.

WRIGHT, or BUDD MINE, north of Stanhope, Sussex county.

Work was suspended here a year or more ago.

Annual Report, 1879, pp. 78-79.

" 1880, p. 114.

SILVER MINE, near Stanhope, Byram township, Sussex county.**HAGGERTY MINE, near Stanhope, Byram township, Sussex county.****LAWRENCE MINE, near Stanhope, Byram township, Sussex county.**

Notes of these mines in

Geology of New Jersey, 1868, pp. 621-622.

Annual Report, 1873, p. 67.

LAWSON OPENING, near Byram cove, Byram township, Sussex county.

Annual Report, 1880, p. 127, (Lawless.)

GAFFNEY MINE, Byram township, Sussex county.**SICKLES MINE, Byram township, Sussex county.**

The northeast shaft of Sickles mine was pumped out in the autumn of 1882, and examined with a view to its being worked for the Sparta Mining Company, but no ore was raised. The mine is reported to have produced 2,000 tons of rich ore, suitable for Bessemer, and the vein is said to have an average breadth of four feet, between a good hanging wall and an irregular foot wall.

Annual Report, 1873, p. 67.

" 1879, p. 79.

" 1880, p. 115.

SHERMAN FARM OPENINGS, east of Sparta, Sussex county.**BUNKER FARM OPENINGS, east of Sparta, Sussex county.**

Annual Report, 1879, pp. 79-80, (Sherman and Bunker.)

OGDEN MINES, Sparta township, Sussex county.

The Ogden mines group includes the Davenport mine, at the southwest, then the Roberts mine, the Pardee-Ogden, and the old Ogden, or Lehigh mine. Only the Pardee-Ogden has been in operation during the year. The present mining is on a large shoot of ore which pitches to the northeast. The northeast end of the stoping is 300 feet beyond the foot of the shaft. The walls are vertical. The bottom rock runs nearly level, but descending slightly to the northeast. At the top the ore pinches to size too small for removing the ore profitably, and the roof is arched. The height of the shoot is 85 feet; its average breadth, 14 to 15 feet. As the ore thins out in the roof, or cap rock, the actual limit in that direction is unknown, but in the bottom the ore is all removed, and there does not seem to be any more at greater depth. In these respects this shoot is much like that of the Hurd mine. It will be of interest to ascertain what the pinched *vein* in the roof may lead to, and to prove the absence of any lower shoots belonging to the same *vein* or ore bed.

At a distance of 100 feet from the northeast heading, the *vein* is offsetted into the southeast or hanging-wall side (as go northeast). The course of the fault is nearly at right angles to that of the *vein*, and the plane of the same dips steeply south-southwest. The amount of break is two feet more than the ore breadth, and a thin leader of ore connects the two on the hanging-wall side.

The main hoisting shaft is now on the top of the hill, and beyond it, to the northeast, is the pump shaft. One 14-inch plunger pump, 5½ feet stroke, working 6 to 7 revolutions per minute, raises the water. As the walls stand up so nearly vertical and are firm, no timbering of any amount is needed to keep them up. The mine is worked by A. Pardee & Company, and the ore is used at their furnaces at Stanhope.

This Ogden mines range has been traced southwest nearly two miles, but the openings beyond the mines proper have shown the ore to be lean.

• Geology of New Jersey, 1868, pp. 631-632. .

Annual Report, 1873, p. 68.

" 1879, p. 80.

" 1880, p. 115.

GREER FARM OPENINGS, Hardyston township, Sussex county.

HOPEWELL FORGE TRACT, Hardyston township, Sussex county.

Annual Report, 1873, p. 68, (Greer and Hopewell.)

" 1879, p. 80. " "

" 1881, p. 38. " "

CANISTEAR MINE, Vernon township, Sussex county.

TRACY AND CRANE FARMS, Vernon township, Sussex county.

HENDERSON FARM, Vernon township, Sussex county.

For notes of these three localities, see

Annual Report, 1873, p. 70.

" 1879, p. 80.

" 1880, p. 115.

WILLIAMS MINE, Williamsville, Vernon township, Sussex county.

The Williams mine is named from the Williams estate, on which it is located. It has been worked at irregular periods during the past ten years. For a time it was leased by Fritz and Martin. Since that lease, Joseph Wharton, of Philadelphia, has had it, and it was in operation for two years—up to April, 1883. According to the statements of the owner the main shaft is 200 feet deep, and from it the ore has been followed 175 feet to the southwest, and 100 feet to the northeast, or a length of 275 feet in all. The bottom drift is 60 feet long and the ore breadth 11 feet. The walls are clean and firm. About 400 feet southwest of the main shaft there is a second opening and a whim shaft 30 feet deep. The ore contains pyrite in crystalline masses, scattered unevenly through it, and needs to be roasted. Most of it was roasted in open kilns or heaps walled around with stone. Some very rich coarse granular ore was seen at the mine, which is said to come from the bottom stopes. There was no sulphur in these specimens. As the mine is three miles from the nearest railway station, it has to be hauled by teams that distance, but most of the way to Vernon is down hill.* The ore mined by Mr. Wharton was used in his furnace at Hackettstown. The buildings are of stone and very substantial, and the mine machinery is all in place, so that work can be resumed whenever it is desirable to re-open the mine.

Annual Report, 1873, p. 70.

" 1879, p. 80.

RUTHERFORD TRACT OPENINGS, Vernon township, Sussex county.

HUNT TRACT OPENINGS, Vernon township, Sussex county.

Annual Report, 1873, pp. 70-71, (Rutherford and Hunt.)

" 1879, p. 80, (Rutherford and Hunt.)

*The surface of the ground at the main shaft is 1,370 feet above the ocean, the most elevated iron ore mine in the State, and probably in this Highland range also.

WAWAYANDA MINE, Vernon township, Sussex county.

GREEN MINE, Vernon township, Sussex county.

These mines of the Thomas Iron Company have been described in
Geology of New Jersey, 1868, pp. 632-637.
Annual Report, 1873, p. 71.
" 1880, p. 115.

LAYTON MINE, near New Milford, in Vernon township, Sussex county.

This mine has not been described in the Survey Reports, as it was not visited until in the spring of 1882. It consists of several shafts and trial pits, on a length of 550 feet from northeast to southwest, on lands of Jas. K. Layton, about half a mile east of New Milford and very near the New York State line. The place was first opened in 1878. The mineral rights were afterwards purchased by S. D. Brown, of Paterson. It was re-opened in 1882, and worked until May, 1883, by the Layton Iron Company. When visited, the shafts and pits were only from 10 to 56 feet deep, and the ore thrown out was generally lean, having rock mixed with the magnetite. The attraction is nearly everywhere positive and steady throughout the belt in which the openings were located, promising well for the extent of the ore bed. So far as observed no pyrite or apatite were seen in the ore, and its quality appeared to be such as would make it do for Bessemer.

Since the visit to the mine, it is reported that the depth of the main shaft is 128 feet, and 75 feet of drifts cut from it show an average thickness of 6 feet of ore. The southwest shaft is 45 feet deep, and in ore bed 5 feet across. According to a reported analysis, the ore runs 55 per cent. in iron, with traces of sulphur. It is low in phosphorus.

KIMBLE FARM SHAFTS, near Stockholm, West Milford township, Passaic county.

BUDD & HUNT TRACT OPENINGS, West Milford township, Passaic county.

RUTHERFORD TRACT OPENINGS, West Milford township, Passaic county.

CLINTON TRACT MINE, near Clinton, West Milford township, Passaic county.

WALLACE MINE, north of Clinton, West Milford township, Passaic county.

UTTER MINE, Uttertown, West Milford township, Passaic county.

No reports of the working of any of these localities during the year have been received. They are in the nature of explorations rather than productive mines. For notices in previous annual reports, see following:

Annual Report, 1873, pp. 68-69.

" 1879, pp. 81-82.

WELLING MINE, near Greenwood, West Milford township, Passaic county.

Annual Report, 1876, pp. 52-53.

" 1879, p. 81.

" 1880, p. 116.

CENTENNIAL, or SQUIER'S MINE, near State line, West Milford township, Passaic county.

Annual Report, 1876, pp. 53-54.

" 1879, p. 82.

" 1880, p. 116.

PEQUEST BELT.

SCHULER MINE, Oxford township, Warren county.

Annual Report, 1873, pp. 72-73.

" 1879, p. 82.

" 1880, p. 116.

ROSEBERRY MINE, Oxford township, Warren county.

Annual Report, 1873, p. 73.

" 1879, p. 82.

" 1880, p. 116.

BARTON MINE, Oxford township, Warren county.

Annual Report, 1873, p. 73.

" 1879, pp. 82-83.

SHOEMAKER FARM, Oxford township, Warren county.

Annual Report, 1873, p. 74.

" 1879, p. 83.

REDELL MINE, Oxford township, Warren county.

Annual Report, 1873, p. 74.

" 1879, p. 83.

" 1880, p. 116.

LITTLE MINE, Oxford township, Warren county.

Annual Report, 1873, pp. 74-75.

" 1879, p. 83.

QUEEN MINE, Oxford township, Warren county.

The Belvidere Iron Company works this mine on a lease from the owner, Mrs. Queen. And it is sometimes known as the Belvidere mine. The exact shape of the ore body is yet undetermined, as no regular walls of rock have been reached, and the greater part of the drifting in the ore has been within 60 feet of the surface. The deepest shaft is reported as less than 100 feet. In consequence of the earthy nature of the strata associated with the ore, and the great size of the deposit, it is thought that the place will have to be stripped and worked as a great open cut, or else underground by a much deeper system of mining. The ore is low in phosphorus, and is used for Bessemer. Much of it goes to Scranton, Pa. A branch railroad connects the mine with the Lehigh and Hudson railroad, near Buttzville. The mine was actively worked all the year, and the production was at the rate of 1,000 to 1,600 tons a month. As one of the most recently opened mines of the State, and in this Pequest belt, it is of especial interest, and its development is looked forward to with interest.

Annual Report, 1882, (Queen Mine.)

OSMUN PLACE, Oxford township, Warren county.

Annual Report, 1882, p. 73.

RAUB FARM, Oxford township, Warren county.

Annual Report, 1873, pp. 75-76.

" 1879, p. 83.

PEQUEST MINE, Oxford township, Warren county.

Annual Report, 1873, pp. 76-78.

" 1879, p. 83.

" 1880, p. 116.

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HOTT FARM, Oxford township, Warren county.

Annual Report, 1873, pp. 79-81.

" 1879, p. 83.

SMITH FARM, Hope township, Warren county.

Annual Report, 1873, p. 81.

" 1882, p. 73.

DEATS PLACE, Hope township, Warren county.

Annual Report, 1873, pp. 81-82.

" 1882, p. 73.

HENDERSHOT, or HOAGLAND PLACE, Hope township, Warren county.

Annual Report, 1879, p. 83.

" 1880, p. 127.

COOK FARM, Hope township, Warren county.

Annual Report, 1881, p. 37.

" 1882, pp. 73-74.

KISHPAUGH MINE, west of Danville, Warren county.

At present, one slope only of this mine is in use—No. 3—which runs down on the foot wall obliquely 350 feet. The workings to the northeast, in slopes Nos. 1 and 2, have all fallen in, as the ore has been removed from that part of the mine. On account of the great size of the shoots to the eastward, the pillar and long wall system of mining were employed instead of stoping, as ordinarily practiced in our iron ore mines. The pillars were subsequently removed and the mine allowed to fall in, as has occurred. The average dip of the foot wall is 28° to the southeast; the pitch does not exceed 15° toward the southwest. So far no offsets have been met. The shoot, which is now worked, is 90 feet high and 18 feet wide, with a layer, one foot thick on the foot wall, of rich, hard, black ore, and generally separate from the main mass of the shoot. In the cap rock, over this shoot, a thin string of ore is left as being too small for profitable mining. The searches for other shoots to the northeast of slope No. 1 have failed to discover any ore there. And from the pitch to the southwest it is evident that the Kishpaugh vein will be found in that direction. The discoveries on the Cook farm show its extension in that direction.

Annual Report, 1873, pp. 82-84.

" 1879, pp. 83-84.

" 1880, p. 117.

CORLISS FARM, Hope township, Warren county.

Annual Report, 1882, p. 74.

INSCHOW LOT, Hope township, Warren county.

Annual Report, 1873, p. 84.

" 1879, p. 84.

STIFF FARM, Hope township, Warren county.

Annual Report, 1873, pp. 84-85.

POTTER FARM, Independence township, Warren county.

Annual Report, 1873, p. 85.

" 1879, p. 84.

STINSON FARM, Independence township, Warren county.

Annual Report, 1879, pp. 84-85.

" 1881, p. 37.

" 1882, p. 74.

GARRISON FARM, Independence township, Warren county.

Annual Report, 1873, p. 85.

" 1881, pp. 37-38.

DAVIS MINE, Independence township, Warren county.

Work on the place of Azariah Davis, near the north end of Jenny Jump mountain, was resumed last April by A. Pardee & Co., under the direction of Mr. Tretheway, of Hackettstown. The older openings are on the top of the ridge. The later work of exploring was on the slope west of Davis' house. The ore was discovered 7 feet wide, and bounded by good walls, which dip toward the southeast. It is lean, containing some calcite and other foreign constituents. After working six months in opening the place it was abandoned for the present.

Annual Report, 1873, p. 85.

" 1881, p. 31.

ALBERTSON PLACE, Independence township, Warren county.

Annual Report, 1873, p. 85.

SHAW'S MINE, Independence township, Warren county.

Geology of New Jersey, 1868, pp. 659-660.

Annual Report, 1872, p. 18.

HOWELL FARM, Independence township, Warren county.

Annual Report, 1873, pp. 85-87.

" 1878, p. 101.

CARROLL PLACE, Independence township, Warren county.

Annual Report, 1873, p. 87.

GREEN PLACE, Independence township, Warren county.

Annual Report, 1882, p. 74.

CUMMINS MINE, Independence township, Warren county.

Work at this place was suspended November, 1882. The shaft had been sunk to a depth of 80 feet, and 3,000 tons of ore had been raised from the mine, most of it used at Secaucus. The ore carries some garnet, pyrite and other foreign constituents. No regular walls had been reached. The mine has been worked under the superintendence of Mr. Tretheway, for A. Pardee & Co.

Annual Report, 1881, p. 38.

AYRES PLACE, Independence township, Warren county.

Annual Report, 1881, p. 38.

SCHAEFFER FARM, Independence township, Warren county.

Annual Report, 1873, p. 87.

" 1880, p. 127.

MARING PLACE, Allamuchy township, Warren county.**HIBLER, or LIVESEY'S SHAFT**, Allamuchy township, Warren county.

Annual Report, 1873, p. 87.

" 1879, pp. 85-86.

" 1880, p. 117.

WINTERMUTE'S OPENING, Allamuchy township, Warren county.

Annual Report, 1880, p. 127.

HAGGERTY'S DIGGINGS, Allamuchy township, Warren county.

Annual Report, 1873, pp. 87-88.

" 1876, p. 52.

" 1879, p. 86.

GLENDON MINE, Green township, Sussex county.

Annual Report, 1873, p. 88.

McKEAN, or BIRD MINE, Byram township, Sussex county.

This mine is now idle. When it stopped, the greatest depth reached was about 90 feet. There are two main shafts, 100 feet apart. The dip of the ore bed is toward the southeast at a steep angle. The foot wall consists of rock and ore mixed; the hanging wall is clean. The ore is sulphurous, but is low in phosphorus. The present workings are about 200 feet north of the old mine holes. Mr. Martin, of Newton, the present owner, says that the total product has amounted to 4,000 tons. The mine is one mile from the Sussex Railroad.

Annual Report, 1874, pp. 28-29.

" 1879, p. 76.

" 1880, p. 118.

BYERLY OPENINGS, Byram township, Sussex county.

Annual Report, 1879, p. 86.

ROSEVILLE MINE, Byram township, Sussex county.

The Andover Iron Company re-opened this old mine in 1880 and raised about 1,200 tons of ore. The demand for ores falling off, work was suspended in June of that year, since which date all has been idle.

Geology of New Jersey, 1868, pp. 628-631.

Annual Report, 1873, p. 88.

" 1880, p. 118.

ANDOVER MINE, Andover, Sussex county.

Geology of New Jersey, 1868, pp. 640-657.

Annual Report, 1873, p. 88.

SULPHUR HILL MINE, Andover, Sussex county.

No work has been done in this mine during the year, and the former lessees, W. J. Taylor & Co., have abandoned it.

Annual Report, 1873, p. 88.

" 1879, pp. 86-87.

" 1880, p. 118.

TAR HILL MINE, Andover township, Sussex county.

The Lehigh Crane Iron Company stopped its work here about a year ago. The tunnel which was driven into the side hill with the design of cutting the *vein* at a lower level, discovered ore, in quantity, and bounded by regular walls, but too lean to be worked profitably. This garnetiferous ore appears to replace the richer ore which

was opened on the surface to the northwest. The work of exploration, while practically a failure so far as the development of additional mining ground was concerned, has given us a striking example of the replacement of magnetite in part by garnet.

Geology of New Jersey, 1868, p. 657.

Annual Report, 1880, p. 118.

LONGCORE'S MINE, Andover township, Sussex county.

Geology of New Jersey, 1868, pp. 657-658.

STIRLING HILL MINE, Sparta township, Sussex county.

This mine was abandoned by the Franklinite Iron Company more than a year ago, since which date it has been idle.

Annual Report, 1877, p. 52.

" 1879, p. 87-88.

" 1880, p. 118.

HILL MINE, Franklin Furnace, Sussex county.

FURNACE VEIN MINE, Franklin Furnace, Sussex county.

The Hill mine was abandoned in February, 1882, and the Furnace mine in November, 1881. There was so much rock in the *veins* that it did not pay to work them. Much dead work in drifting and boring with the diamond drill failed to discover other shoots. The series of shoots opened in the Furnace mine was so well marked above that a greater regularity was to be expected below than the searches indicated.

Geology of New Jersey, 1868, pp. 658-659.

Annual Report, 1873, p. 88.

" 1879, pp. 88-89.

" 1880, p. 118.

GREEN'S MINE, Vernon township, Sussex county.

BIRD MINE, Vernon township, Sussex county.

Notes of these two mines in

Geology of New Jersey, 1868, p. 660.

Annual Report, 1879, p. 89.

VII.

EXPLORING FOR MAGNETIC IRON ORE, AND
LOCATING MINES.

The practical miner, in his work of exploring and of mining iron ores in the Highlands of New Jersey, has to face the difficulties which arise from the more or less complicated structure of this district. From the start he must be prepared to find pinches, faults or offsets, which may cut the ore bed at any angle and throw the ore away to right or left, up or down, reversed dips, reversed pitch, and often a combination of these disturbances or irregularities in structure, making the problem still more intricate. Hence, the necessity of a practical acquaintance with the mode of occurrence and the peculiar features which are less commonly observed. The knowledge of these elements may be acquired through personal observation of many localities. The study of reports, of mine surveys and maps and of geological structure may serve in place of the more expensive method of personal inspection. In any case, these descriptions by others are valuable helps, which should be used by every practical man wishing to become thoroughly informed upon this subject. Many of the failures in mining enterprises and in mine management in the State are owing to a lack of this acquaintance with the modes of occurrence of the magnetic iron ore, or a disregard and consequent want of caution respecting them. The methods of opening and of working are not suited to the place. Often the manner of exploring is not adapted to make a thorough search. The abandonment of a locality by one explorer and the success of another coming afterwards, in so many localities, is explained by the more careful observations and more cautiously conducted method of searching by the second party. Many of the so-called mines and openings in the preceding list are examples of this kind. But the most experienced and best informed mine super-

intendents find their way continually beset with difficulties and perplexing problems. Questions about the best and most systematic plans of working a well-defined *vein* or ore bed, arise from time to time. Then, the proper management of a mine is always looking for its reserves in cases of emergency. Hence, the need of exploration going forward with the extraction of the ore in sight. A wise plan includes provision for more than immediate wants. And here also comes in the choice of that direction which the work should take to make the most of all the varied resources of a good mine. In many of our iron mines little work is done in opening more length than the existing force can occupy to good advantage. Many of them are driven nearly to their capacity so far as the development of the ore beds indicates. In some of the larger mines the exploring and opening of new shoots and increased lengths of working stopes is kept well ahead of immediate needs.

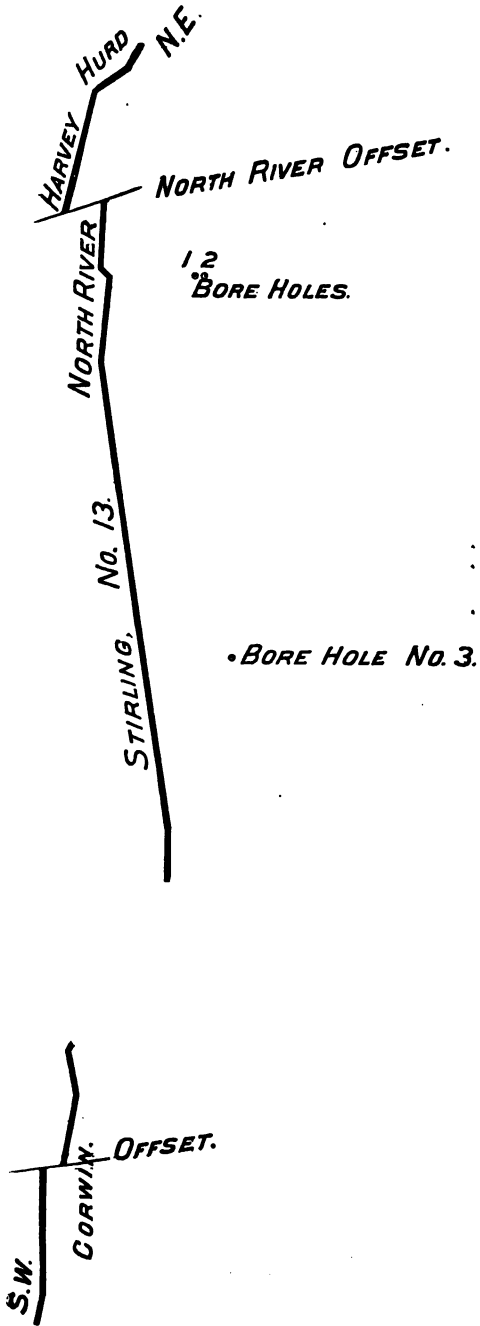
Some of these problems which perplex the miner and interest the student of geological structure may be here indicated briefly. At Mount Hope, for example, the northward extension of the Taylor or Jugular *vein* in Hickory hill remains to be discovered. To the southwest, in Teabo hill, explorations are now in progress for this same *vein*. From the existence of the Teabo *vein* in this hill, as opened in the Teabo mine, it is reasonable to expect to find its companion to the west of it. Going south, at the Allen mine, there are very serious questions, and upon their solution may depend the future working or abandonment of the place. Expensive tunneling and boring with the diamond drill, in search for the so-called Powell vein (of the Richard mine), have thus proved unsuccessful. And yet it cannot be said that these searches were not well directed and necessary. The question is still unsettled whether the *vein* of the Allen mine is identical with that at the southeast, in the Richard mine. As referred to elsewhere, the explorations are incomplete, and there remains to follow the large Richard shoot down, on its northeast pitch, passing the offset, to the Allen line, and beyond on the latter property. The Richard mine is now working on a great length of ore, and is not troubled with pinches or serious faults. But how soon these untoward conditions may come! A few months might make a very different showing. Adjoining it, at the southwest, is the abandoned Baker mine, whose broad and regular *vein* was selected as typical of regularity, and surveyed and mapped to show this feature. The ore pinched out in the bottom and three bore-holes by the diamond drill failed to find any workable thickness

at greater depth. The question is asked by practical men acquainted with the mine, Where has that large and regular shoot of ore gone? The northeast extension of it is on the Richard property. But are there not other and equally large shoots below? On the long Mount Pleasant mine property there are numerous faults, and the displacements they produce require much care and skill in again finding the ore. And that the *vein* deeper will be found offsetted is probable. These offsets and cross-slides, as here met with, bring an element of uncertainty as to the probable extent of the ore to be obtained here, although so far the mining management has succeeded in getting through them. Southwest of Port Oram, in the Irondale mines, two very large offsets are recognized in all the mining directions. But beyond the Stirling, to the southwest, there is a gap or break of 700 feet in the line, where no ore bed has been found. From the form of the shoots *bottoming* out at the southwest in the Stirling, it seems as if there must be a long pinch here, combined, perhaps, with faults, as the courses of the Corwin and of the Stirling outcrops indicate; and the existence of a workable shoot at a considerable depth from the surface is not altogether improbable. At the celebrated Dickerson mine the shoots are so irregular in shape that their size at any great distance beyond the working section is almost speculative. Rolls in the walls, retreating cap-rock and other irregular features may appear at any time to alter the dimensions of the shoot. What may be termed the usual and continued irregularity here is, however, to some extent, a warrant for the persistence of these shoots to great depths. The relation of the three shoots to one another is still a problem. Some of the difficulties which are most prominent in that nearly unbroken range of ore, from Mount Hope to the Dickerson mine, have been stated. They are typical of what are to be found in all the large mines elsewhere in this iron-ore district. In fact the problems outside of this range are in general more serious and troublesome, affecting in many cases the existence of mines. To mention all would be to go over the list in detail. In many cases it would be invidious to publish them. And there is scarcely an iron mine in the State where there are not some questions of this kind which cause some anxiety to both owners and superintendents.

These general statements, with a few notable examples, have been given to impress upon mine owners and superintendents the importance of more attention to the study of how these iron ores occur, and especially how the ore beds may be disturbed by faults, pinches, &c.;

and a more careful preservation of records giving facts about such disturbances. Hence, also, the great need of frequent mine surveys. Many of our companies keep them close after the work. Other large mines have not been surveyed at all. Neglect has been, in several cases, the cause of expensive litigation; in others, of badly located plant, and the loss of valuable data for future reference. The work of the Geological Survey cannot take in all this detail. Its province is to map the surface, and locate the mines and ore beds; and gather all the available data, and so arrange them as to throw the most light upon the dark and difficult points, and thus make plain the structure of the whole district. The surveys of the surface are nearly completed. Maps of certain areas, or ranges of ore, on a larger scale, may still be essential. But, better than these representations of the surface, would be a map of the whole underground work. And this most-to-be-desired end can be secured only through the co-operation of all the mine owners. A map of this kind, showing the exact relation of mine to mine, would give us at a glance the whole series of shoots, pinches, faults, cross slides and other features, and would, without doubt, suggest the lines and points for further explorations. Until this aim is reached, an important part of our work is the dissemination of such information as will stimulate searches in the proper location, and prevent others which are altogether hopeless. The explorer is not only to be guided, but also to be cautioned against a waste of capital and energy.

Directions or rules for the guidance of those searching for new beds of iron ore have been given in previous reports of the Survey. They do not altogether cover the cases, such as have been referred to above. And recourse must be had to some economical and quick mode of cutting through the strata. For this purpose the diamond drill is used advantageously. Its employment in New Jersey has been confined to a few localities. In the West, particularly in the Marquette and Menominee iron ore regions of Michigan and Wisconsin, it has become indispensable and the success attending it has been very great. At Port Henry, New York, and at other points in the Adirondack region, this drill is used to ascertain the size and shape of the ore bodies. Two localities where the diamond drill has been used to advantage, may be here referred to as illustrations of good work. The first is at Irondale, Morris county, where three holes were put down at the east of the Stirling mine outcrop. The accompanying page map of the *vein* shows the position of the bore holes.



RANGE OF MAIN IRONDALE VEIN.

SCALE, 1 IN. = 800 FT.

FROM A MAP & SURVEY BY L. C. BIERWIRTH.

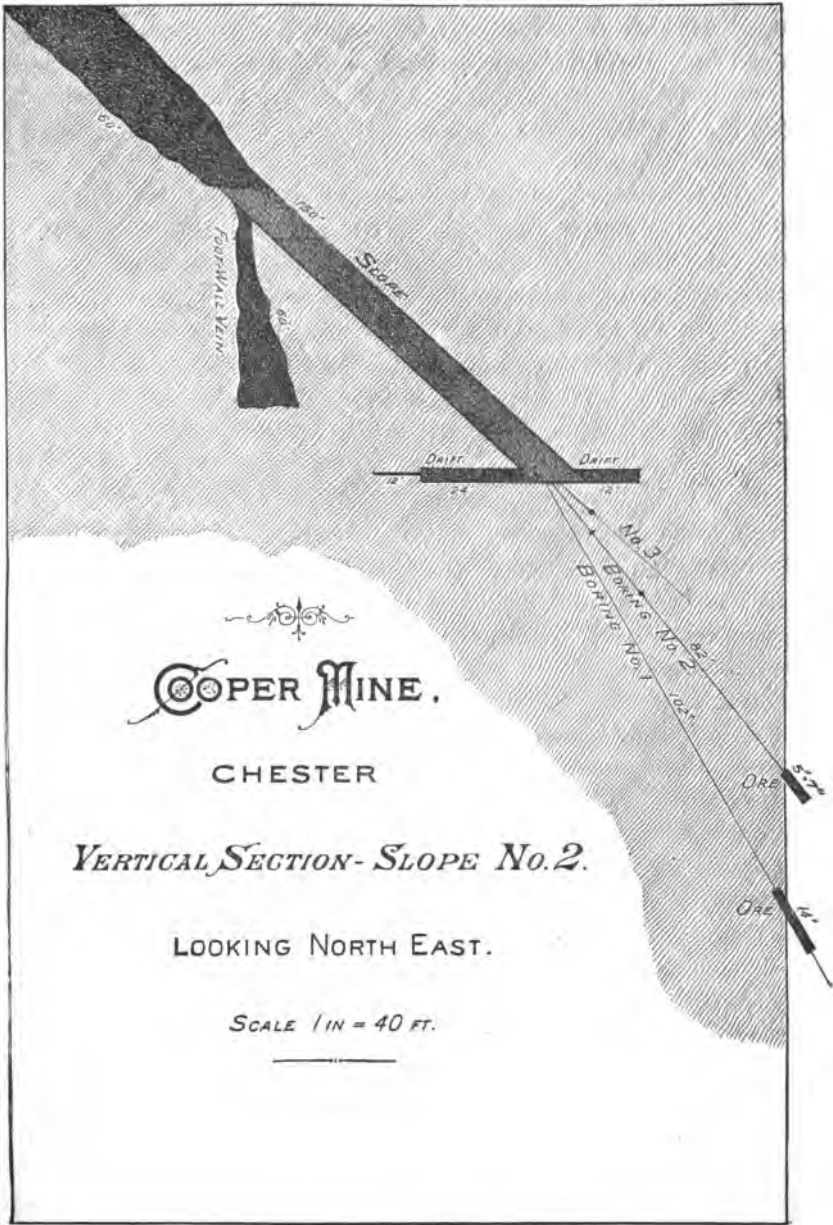
In bore hole No. 1, the depth reached was 338 feet. The ore was 4 feet 7 inches thick. In No. 2, the ore was 15 feet and 6 inches thick, and the depth 365 feet. These are vertical measurements. Hole No. 3 is 501 feet deep, but no ore was struck. The failure of No. 3 to strike the ore is explained by the descent of the shoot of the Stirling to the northeast, beyond No. 3. It ought, however, to have struck any shoot coming from the southwest, unless there is a broad pinch here, in which case a much greater depth would be necessary to strike any shoot below it. The discoveries in holes Nos. 1 and 2, prove the continuation of the large Stirling, or No. 13 shoot, beyond the present workings. Additional bore holes are desirable to test the gap, or break, between the Corwin and the Stirling mines.

The explorations by Mr. Evans, in the Cooper mine at Chester, have been referred to on page 93. A vertical section at right angles to the ore beds is inserted on the opposite page to show the results of this work.*

The ore having been *cut out* by the bottom rock coming in its place, the slope was continued on the dip of the foot wall to a depth of 150 feet; and, as no ore was found, borings were then made as follows: No. 1, at an angle of 60° ; No. 2, 50° , and No. 3, 45° . In No. 1, the ore was found 14 feet thick at a depth of 103 feet. In No. 2, it was met with at a depth of 82 feet, and it was there 5 feet 7 inches thick. No. 3 was stopped at about 40 feet down, as the work was then suspended. These discoveries by the drill are interesting, as they indicate other shoots of ore below that worked at the surface.

The success which has attended the use of the diamond drill at these points is suggestive and instructive. One disadvantage is that the dip of the strata is not easily made out from the cores, and a boring might traverse a bed in the plane of its bedding, or at so small an angle with the dip as to indicate a great thickness of the same bed, and, if it were ore, give a false impression as to its thickness. But where the dip is so generally uniform, as it is over wide areas of the iron ore region, there is little error to anticipate from this source. And, in piercing stratified rocks, the lamination or parallel arrangement of the minerals should be seen in circles around the cores if the boring is at right angles to the bedding, as it should be, in order to expose the most beds. As the dip is generally at angles of 45° to

*The data for this section were kindly furnished by Mr. John D. Evans, superintendent of the mine.



60° to the southeast, to do this the boring must be directed to the northwest at angles of 30° to 45° from the horizon. The use of the diamond drill is preferably recommended in searches for the continuation of shoots or ore beds already known and partly opened. And hence its employment in or about mines in searches for additional ore, either in the line of the vein or to test the ground on the sides of the ore.

The cost of boring is so much affected by varying circumstances, as the variety of rock, the angle of the hole, the supply of water for steam, as well as the skill of workmen, that no figures can be given. The range may be stated as from \$3.00 to \$6.00 per lineal foot. In exploring for new beds of ore, the drill is not to be recommended, at least not until searches have been made by means of trenches and test pits or shafts.

EXPLORATIONS FOR IRON ORE BY THE MAGNETIC NEEDLE.

The magnetic properties of the ore are very marked and are well known. Specimens taken from near the surface, are in many cases good and permanent magnets. And in some places the whole mass of ore is so highly magnetic as to cause the steel tools used in working it to become permanent magnets and capable of attracting other pieces of iron or steel.

The principal portion of the ore, after it is mined, is not permanently magnetic itself, but it is always capable of being attracted by the magnet, and hence its name of *Magnetite*. Its properties in this respect are like those of good, soft wrought iron.

As the ore lies in the earth in great sheets or flattened masses, it is influenced by the earth's magnetism just as a mass of iron is when it is placed in the same direction and with the same inclination. Most of the beds of magnetite in New Jersey stand on their edges and inclined downwards at various angles of dip, and the general direction of the upper edges is northeast and southwest. They are in most cases covered by a few feet of earth, or sometimes of rock, and when a miner's or a surveyor's compass is carried over it the needle is drawn out of its proper direction; in most places over a bed of ore the north end is drawn downwards, but in some places on the bed of ore the south end is attracted. The attraction of ore for the compass-needle is well known. The explanation and significance of the differ-

ent attractions need attention and study, and to further this end, as well as to induce a larger number of persons to engage in investigating this subject and giving it practical application, the following particulars are given, though most of them have been in former reports:

I. The instrument used in investigating this subject and in applying it to the search for iron ores, is the magnetic needle. This needle is fitted for use in two different ways: first, as in the surveyor's compass and the mariner's compass, where the needle, which may be from one to six inches in length, is carefully balanced on a vertical center-pin and has a motion from side to side around this pin; second, as in the dipping-needle and the miner's compass, in which the needle is mounted on a horizontal axis so as only to have an up-and-down motion about its axis. When the magnetic needle is free to move, it arranges itself so as to stand in a northerly and southerly line, in most places not exactly north and south, but in New Jersey, at this time, it points about N. 6° W. and S. 6° E., which is commonly called the *variation* of the needle. And the needle, which is balanced so as to stand level before charging with magnetism, will, after it is charged, if properly placed, stand with its north end inclined downwards at an angle in this latitude of about 60° . This is called the *dip* of the needle.

The two ends of the needle are called its "poles." The one pointing towards the north is the north pole, and the other the south pole. If either pole is brought near iron filings, or small pieces of iron, or magnetic iron ore, it attracts them, but if brought near the poles of another magnet, there is an attraction between the poles of different kinds and a repulsion between poles of the same kind; that is, a north pole attracts a south pole and repels another north pole, and a south pole attracts a north and repels a south pole.

II. When a bar or rod of soft iron lies horizontal with its two ends pointing east and west, it is attracted by either pole of the magnet, and has itself no magnetic properties. But if the same rod is stood up on end, and then tested as to magnetism, it will be found to be magnetic, and its upper end will attract the north pole of the magnetic needle, and its lower end the south pole. In other words, it is a magnet, having its upper end a south pole and its lower end a north pole. It is, however, only a magnet in consequence of its position, and will lose all its magnetism the instant it is laid down in an east

and west direction ; and if it is again stood up, but upon the opposite end from that in the first trial, and then tested by the magnetic needle, the upper end will attract the north pole of the needle and the lower the south pole.

The magnetic polarity in the iron rod is due to the influence of the earth's magnetism, and it is most powerfully developed when the rod is in the position naturally taken by the dipping-needle ; that is, when the rod stands with its upper end inclined towards the south, at an angle of 60° from the horizon. If the rod is not exactly in this position, its magnetism is developed in the same way, but not so strongly, and it is less and less as it approaches the east and west position, though not all lost until very near that.

The earth's magnetism produces the same effect on the beds of magnetic iron ore that it does on the iron rod. The beds of iron ore which stand in great sheets between the beds of rock, and incline so that their edges come to the surface, are made magnets. Most of the beds have their outcropping edges extending along in a northeast and southwest direction, but pitching underneath the surface towards the northeast. In all these, when the compass is passed over them, the north pole of the needle is drawn towards the ore, just as it was towards the upper end of the iron rod. In passing along over the bed of ore towards the northeast, the attraction may grow less and less as the ore descends farther beneath the surface, until it is too far down to affect the needle ; or else, if the ore comes to an end or an offset, a north pole is developed in it, and then it attracts the south pole of the compass, just as the lower end of the iron rod did. This is called *negative attraction*. In the thicker beds, which crop out in a northeast and southwest direction, and which have a southeasterly dip, while there is positive attraction over the great mass of the ore, there is negative attraction developed along all its northwestern margin.

The attraction is strongest in those beds which have the steepest dip, and which have their strike nearest to a north and south direction ; and in those beds which are nearest to an east and west direction the attraction is the lightest. The attraction also varies in strength with the distance from the compass to the surface of the ore, there being in almost all cases a covering of earth over the ore of from one to one hundred or more feet, which, of course, lifts the compass to that extent farther from the ore, and lessens its action in a proportion much greater than that of these simple numbers.

To make such examinations accurately, the best and most delicate compasses should be used, and the whole ground be carefully examined by both horizontal and dipping needles, before concluding upon locations for exploring or opening mines, or sinking shafts, or beginning expensive works of any kind. With experience in the use of the magnetic needle, and a judicious study of its indications, locations can be made with a good degree of certainty, but in the hands of unskilled men its indications may be interpreted so as to produce much disappointment and pecuniary loss.

After the ground to be tested has been carefully surveyed by using a dip compass, or still better, after a magnetic survey with the dial or horizontal compass has been made, the quickest and simplest mode of exploring is by trenching to the rock or strata. The trenches should run across the belt of attraction, and at right angles to the strike or course of the rocks and the supposed ore bed. They can be located at distances of 50 to 200 feet apart, according to circumstances. From the results or discoveries made by thus uncovering the strata in sections across their strike, the location of the working shafts may be determined. In the iron ore region of New Jersey trial shafts are generally sunk first, and are located on the center line of the belt of attraction. Trenching is not common. Those who are familiar with the working of the miner's compass by long experience can locate trial shafts with some degree of certainty of striking the ore. But they are often in error, though it be only a few feet, and yet enough to barely miss the ore bed. In the history of our mines failures like this are not uncommon. South of the glacial drift or terminal moraine, in the southwestern and southern parts of Morris county, in Hunterdon, and in Warren county south of Hackettstown and Oxford Furnace, this method of opening the surface is generally practicable. But north of the moraine line, in the northern parts of Morris and Warren counties, and in Sussex, Passaic and Bergen counties, the glacial drift is in places too thick to allow of this mode of exploration. Where the covering of the rocks is of more recent age, as in the alluvial deposits of some of the valleys and smaller depressions, the distance to the rocky substratum may be too great to be reached in this way.

In any case the outcropping ledges are to be examined and the course of the bedding to be ascertained, and also the dip, if possible. The magnetic iron ore is found in beds conformable to the rock strata,

unless it occurs in a dike or vein which is of irregular shape, and cuts across the more common gneissic strata. This latter mode of occurrence is more rare, and generally of no economic importance. It may be recognized by the absence of any signs of bedding and without division into layers. The beds of ore come to the surface or crop out under the overlying earth generally, and hence the searches should be directed to finding these outcrops. Where the shoots are covered by cap-rocks, the outcropping end of the shoot (or, as it is sometimes termed, the *tail of the shoot*,) is not so easily discovered, and a trench or trial shaft might pierce the cap-rock, yet fail to reach the ore. But the attraction must guide to this point, and trial shafts should not be driven into the solid rock unless there is positive proof of ore underneath it. As a rule, shafting in rock is the most expensive and the least successful mode of exploring. Failures without number result from a neglect of this caution. The small capital of the prospector is soon wasted. Whether at the surface or in the mine, a good rule is not to get far away from the ore, but follow it.

NOTE.—The dip compass made by W. & L. E. Gurley, of Troy, N. Y., was first made by them specially for our work, and is a good instrument. Small compasses, with horizontal needles, of many different patterns, are in use; but that with a sun-dial upon it is fitted for doing the best work, as with the sun shining, and a good time-piece, the north and south line can be found, however much the needle may be disturbed by local attraction.

VIII.

DRAINAGE.

The drainage of the Great Meadows, on the Pequest, in Warren county, continues to show its efficiency. The deepened channel carries off all the waters of ordinary rains within its banks, and the slight overflows which have been noticed, after one or two extraordinary rains, have quickly subsided without injury. The owners of this former swamp land are gradually bringing it under cultivation, and wherever it is cropped, it shows a decided superiority to any of the surrounding high grounds. The salubrity of the whole country in and around the meadows is unquestioned; and the autumnal and miasmatic diseases, formerly so much dreaded, have disappeared.

The plans for the drainage of the drowned lands on the Wallkill, and the flowed lands on the Passaic, which were prepared and published in the annual reports of the State Geologist for the years 1869, 1870 and 1871, have not yet been put in course of execution.* The drainage of the lands is of great public importance, both for increasing their value and productiveness, and for the sanitary benefits it would bring to the near inhabitants and to the State. It is hoped that means will soon be found for improving them by drainage, as well as to abate the public nuisance which they are in their present condition.

*The drowned lands are all represented on sheet No. 4 of the new topographical maps of the Geological Survey. This sheet covers the whole tract to the outlet canal. The course of the Wallkill, the surrounding hills and mountains, and the elevations above ocean level, are shown by it. In that part of the tract which is in New Jersey, the upland islands, the wooded portions, the grassy lands, and the wet meadows, are indicated.

X.

MISCELLANEOUS.

NATIVE IRON.*

Native iron has been found in small quantities both in the shale and the earth, in Raritan township, Middlesex county, about three miles east of New Brunswick, and one mile southeast of the village of Piscataway.

In the summer of 1882, an attempt was made to deepen the well on the Van Horn farm by boring. The shale was reached at the depth of 21 feet, and continued in it for the whole depth bored, which was 74 feet. There was not much water found, but at the depth of 50 feet it was observed that when the drill was raised from the well there were numerous particles and small grains of iron adhering to the lower end of it. This attracted the attention of Mr. James F. Hotchkiss, of Plainfield, and the boring was continued further at his

* Native iron has been found at comparatively few points in the earth's surface. A very full description of undisputed localities or occurrences is in Poggendorf's *Annalen der Chemie*, Vol. LXXXVIII., page 145, by J. G. Borneman, in an article entitled *Native Iron from Keuper, at Mühlhausen, in Thuringia*.

At this place the iron was found in the center, or as kernels in small spheroidal masses, or balls whose outer shell consisted of magnetite and limonite or of pyrite in part. These balls occur in a coaly layer which is termed *Kohlenletten*, and which is fossiliferous also, carrying abundant remains of plants. Over it is a clayey sandstone containing *calamites*' remains. Its thickness is from six to nine inches. The largest of these *iron balls* weighed 40 grammes. A chemical examination of the iron failed to discover any nickel or cobalt. The metallic portion was of irregular shape, enclosed within the black, magnetic hull. The outer crust was partly limonite.

The metallic iron found at Kamsdorf, in Thuringia, showed on analysis 92.5 per cent. of iron, and 6.0 per cent. lead and 1.5 per cent. copper. It weighed 12 ounces and was associated with magnetite.

Native iron exists in small plates and tabular shapes in the platinum and gold sands of the Urals in Siberia and in South America. These are of steel gray color and consist of metallic iron, 86.33; platinum, 8.15, and insoluble 4.50 parts.

hearty endorsement and support of the people most deeply interested. The officers of the Survey have been glad to furnish such geological information as would help in settling the questions they have had under consideration. And it has given us great satisfaction to see that our topographical surveys and maps have been sufficient to furnish the basis for their work, to save them a great deal of time and labor, and to enable them to accomplish in a single season what would otherwise have been entirely beyond the means provided for them.

During the year the cities of Orange and East Orange have completed the construction of public water-works in a satisfactory manner, and are enjoying the benefits of an abundant supply of good water.

The locations for the collection and storage of water within our State are sufficient for all the demands of the largest population; but there is need for constant watchfulness to keep the streams free from pollution, and to preserve the water for its most important use, that of the household.

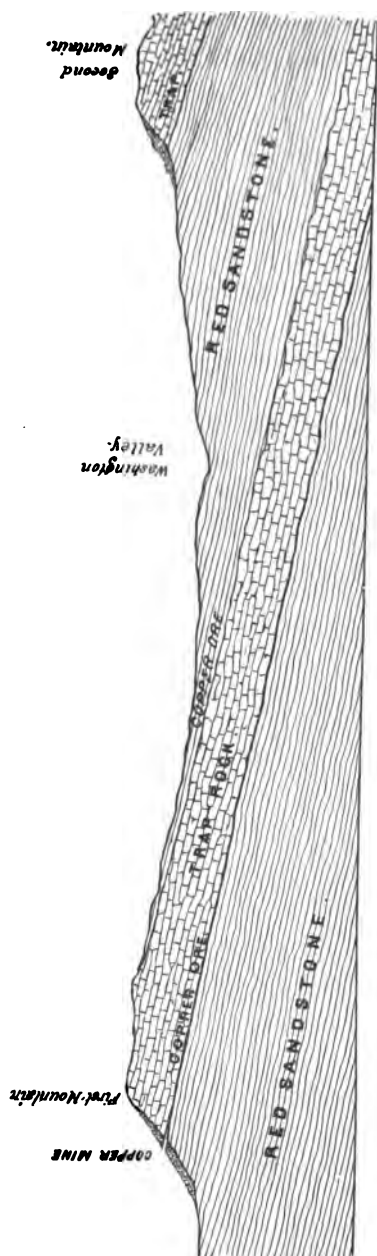
Dr. P. T. Austen, of Rutgers College, is engaged upon a second analysis of the metal. He has not yet completed it, though he reports that he has found a little copper in it. The subject is an interesting one, and though not of any economical importance it suggests inquiries and investigations quite new and different from those heretofore made.

COPPER ORES.

In the annual report for 1881, mention was made of the renewal of work at the old Bridgewater copper mine, near Somerville, in Somerset county. This mine had become the property of A. H. Hovey, Esq., of that place, and he had driven in tunnels immediately under the trap-rock of the First ridge of the Watchung mountains, and had found a fine show of rich ore, yielding 15 per cent. of metallic copper. Since that time Mr. Hovey has made further explorations, by driving a tunnel directly in under the trap-rock of the mountain, a distance of 228 feet, and cutting side drifts off from the main one to the extent of 240 feet, so that these exploring galleries together have a linear extent of 468 feet. In all these the bed of sandstone next the trap-rock, for a thickness of from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet, was rich in copper. The galleries are about five feet wide, and the ore which has been taken from them is mostly piled upon the dumps, and is roughly estimated at 250 tons. A sample of the ore, made up from pieces taken from the ends of all the galleries opened, was assayed, and found to contain 19 per cent. of copper and 6 ounces of silver to the ton of ore.

This is the most extended and promising opening that has been made upon the copper-bearing rocks of this vicinity. The occurrence of copper in its metallic form and as oxide and carbonate, in the triassic rocks, has been noticed from the earliest settlement of the country. Sometimes the copper is found in the red sandstones and shales where no trap-rock is known to be near it, but in most cases the copper ore is in the sandstone immediately in contact with the trap. And it is probable that in the cases where the ore appears in sandstone and no trap is visible, that the latter rock is not far beneath.

The ores of copper have been found along the First mountain, at the meeting of the trap and sandstone, all the way from near Pluckamin to Chimney Rock, and on to the gap in the mountain back of Plainfield. They are seen both in the underlying and overlying



SECTION OF FIRST MOUNTAIN NORTH OF SOMERVILLE.

Scale, Horizontal and Vertical, 1200 ft. = 1 inch.

sandstones and shales; but from the structure of the rocks, they have been more easily uncovered and tested, on the westerly and southwestern face of the mountain, where the underlying sandstone meets the trap.

The position of the trap, as an igneous rock intruded between the layers of sandstone, and constituting a great sheet of peculiar rock, along which copper ores are found on both its under and upper faces, is easily understood and remembered. And it gives direction and encouragement to pursue a more systematic method in exploring for these ores, and for mining them when proper explorations have been made.

The numerous unsuccessful attempts which have been made to mine and work these triassic copper ores, have led to a great distrust of their value. But the fine exposure of ore in this new opening, the better understanding of the geological origin and structure of the rocks bearing the ore, the improved methods used in smelting ores, and the enormous amount of such ores which can be obtained, all give encouragement to renew the efforts to mine and work them profitably.

The section shown on the preceding page, across the First mountain, Washington Valley, and on to the Second mountain, shows the sandstones and trap-rocks in their relation to each other. The section begins $3\frac{1}{4}$ miles north of Somerville, and extends northeast for $1\frac{1}{2}$ miles. The scale of the section is 1,200 feet to 1 inch. The workings for copper ore have been driven in only 228 feet, but thus far the under surface of the trap follows the bedding of the sandstone, with a dip of 11° , and as the overlying sandstone on the northeast slope of the mountain follows down at the same angle of dip, and is charged with copper ore in the same way quite to foot of the mountain, it seems probable that this intrusive sheet of trap, with its accompanying copper ores, continues its regular course between the beds of sandstone for the whole breadth of the mountain, and perhaps much farther, underneath the sandstones of the valley and the Second mountain.

The copper mines at Belleville, at Flemington, at Griggstown and at New Brunswick, have all shown fine specimens of copper ore, but they are not now worked. With the accumulation of capital, the greater skill in mining and metallurgy, the better understanding of the geological associations of the ores, and the unequalled location of the mines for labor, fuel and markets, attention may fairly be called to their claims.

ZINC ORE.

A new locality of zinc ore has been discovered during the year, on the Raub farm, between Buttzville and Oxford, in Warren county. It was opened by Messrs. Hartpence, of Buttzville, and the property has been leased by them and A. J. Swayze, of Hope. The ore was discovered in a thin vein in a ledge of white crystalline limestone, at the north side of the Oxford road, and southwest of the Raub farm house. A test pit is being sunk on the outcrop. The size of the vein and its relations to the limestone strata had not been ascertained at last reports from the lessees. This rock dips to the northwest. The zinc ore is apparently scattered through the rock, and it may not be limited to a single layer or stratum. The ore is a fine crystalline black blende. Specimens have been received at the Survey office, but no assays or analyses have been made of them. Zinc blende in limestone was opened on this farm a few rods southeast of this locality in 1875.*

GRAPHITE, PLUMBAGO, BLACK LEAD.

The localities where this mineral occurs in quantity in the State have been described in previous reports.† The only locality which has been developed to any extent is that near Bloomingdale. It is owned by the Bloomingdale Graphite Company (M. J. Ryerson & Sons), H. J. Dreher, Superintendent.

The old mine was re-opened in the season of 1882 and about 300 tons of lead taken out, mainly from a drift started from the shaft 30 feet down and running in a northeast course. The thickness of the graphitic beds was found to be at least 16 feet, though no walls were reached. The present surface work is north of the old shaft, a few yards, where the beds were supposed to be near the surface. The mine was 60 feet deep.

The large stock of material thrown out by the old company, with that raised last season by the present operators, has sufficed for the works since they have been going. The works are southeast of the mine, about 300 yards, and near a small stream. The old pond is used as a storage reservoir; a new dam lower down and near the

* Annual Report, 1875, page 36.

† Annual Report, 1879, pages 153-156; Annual Report, 1880, page 178.

works gives 40 feet fall. But the motive power is mainly supplied from a large steam engine. The ore is broken, crushed and then separated into the various grades, according to its fineness and purity, for electrotypers' use, for lubricating, for crucibles, founders' facings, stove polish and pencils. The present capacity is about 1,000 pounds a day, and a ready market takes the manufactured article at good prices.

The great extent of the graphite in the gneissic strata at this locality, the convenient arrangements for working up the raw material, the nearness to railroad and the superior quality of the product form the basis of this new enterprise, and give promise of a rapid development into a large industry.

Another graphite opening, which has not been described in any of the preceding Survey Reports, is near Pottersville, on the farm of C. Fisher. It is in a side hill, a quarter of a mile west of Fisher's house, and south of the road leading to Fairmount Church from Pottersville. The place was opened three years ago by Jacob Castner and E. Potter, who set up some machinery for separating it, but the place was soon abandoned. A shallow cut near the brook shows a graphitic gneiss and a coarse crystalline rock in which the graphite is a constituent. No determinations of the percentage were made.

MASTODON BONES.

The bones of a half-grown mastodon were dug up last summer about 300 feet southwest from the depot, at Corona, Bergen county, by Mr. David Essex. They were in black earth, and two or three feet beneath the surface. The bones were very much decayed, so that but few of them could be recognized. There was a piece of a tusk four or five inches long and two inches in diameter, and some broken teeth, which were much worn, and the crowns of some others which, probably, had never developed roots, and were still in the body of the jaws when the animal died. These crowns of teeth, which were in the most perfect preservation, were three and a half inches long, three inches wide and about one and a half inches high.

DEEP BORINGS IN EARTH.

The accumulations of glacial and of modified drift in the northern part of the State have covered the surface irregularly and obscured

the underlying rocks in the most perplexing manner, in the valleys of the Wanaque and the Ramapo rivers, where the surface is now plain and the earth gravelly or alluvial. Some borings have been made in the Wanaque valley during the past season to ascertain the depth of the gravelly and earthy deposits by L. B. Ward, Esq., of the State Water Commission.

Boring No. 1 "was sunk in the Post's brook outlet, in low ground, a short distance west of the wagon road to Wanaque; depth to (supposed) ledge, 116 feet; elevation to rock ledge above tide, 91 feet. The material penetrated for about 80 feet, beginning at the surface of the ground, was a loose, permeable sand, mixed with more or less small gravel, permitting the free passage of water. Below that level was a bed of very close, fine sand, constituting an apparently retentive bed. At the bottom of this, and immediately overlying the rock, was a layer two feet thick of fine gravel."

Boring No. 2 "was sunk along side the Wanaque river in the narrowest part of the pass between the hills. The rock was found at 59 feet; elevation of this rock above tide is 145 feet. This boring penetrated only loose, gravelly material."

Boring No. 3 "is incomplete. It has been carried down 75 feet through material similar to that of No. 1 at corresponding depth. This boring is situated about half a mile north of No. 1, and in the same relative position as to the Wanaque road as the latter."

"There is a close correspondence between the depth of gravel deposit overlying the rock in the main outlet of the Wanaque valley at boring No. 1 (116 feet) and that observed in the boring made in 1865-6, on John Garrison's farm in the Ramapo valley, when rock was reached 117 feet below the surface of the meadow, boring through a bed of gravel to that depth."

A boring made on Bedloe's island, in the examination of the foundation for the Bartholdi statue, failed to find rock at a depth of 50 feet from the surface. The material passed through for the first 15 feet was fine sand; the remaining 35 feet was hard, compact gravel, with some bowlders, as reported by Alex. C. Chenewith, C.E., under whose direction the work of clearing the foundation was done. The gneissic rock, so abundant in New York city, makes its appearance on the west bank of the Hudson, in Jersey City, and undoubtedly makes the west bank of the river channel down to Robbins' reef, but it must be somewhat below the bottom of this boring on Bedloe's island.

XI. •

STATISTICS.

IRON ORE.

The aggregate tonnage of iron ore over the several lines of transportation which cross the Highlands, from stations in the iron-ore district, amounted, in 1883, to 498,293 gross tons. The total amount reported last year over the same lines was 897,183 tons. If to these figures the amounts received at the furnaces direct by teams, and which are not included in any of the returns of the transportation lines, be added, the total amounts are :

In 1882.....	932,762 tons.
“ 1883.....	521,416 “
A decrease of.....	411,346 “

This decrease is equivalent to 44 per cent. or nearly one-half from the total for last year (1882). Comparing with the reports for 1881, 1880 and 1879, there is a decline nearly to the standard of production of 1879, when the reported aggregate was 488,028 tons.

ZINC ORES.

The tonnage of zinc ore over the lines which carry the product of the zinc mines of Sussex county, to the furnaces using them, amounted, in 1883, to 56,085 tons.*

CLAYS.

The following statistics of clays, mined in the State for the year ending July 31st, 1883, have been kindly furnished by the Bureau of Statistics, through Hon. James Bishop, Chief of that Bureau, viz. :

* Statistics of zinc ores carried by the Delaware, Lackawanna and Western, the New York, Susquehanna and Western, and the Lehigh and Hudson Railroads.

Fire-brick clay..	273,000 tons	=	\$1,056,000
Fire sand.....	69,000 "	=	69,000
Foundry clay.....	20,000 "	=	35,000
Paper clay.....	1,000 "	=	10,000
White-ware clay.....	11,300 "	=	79,100
Stone-ware clay.....	18,000 "	=	54,000
Drain-pipe clay.....	100,000 "	=	175,000
Terra-cotta clay.....	8,000 "	=	24,000
	500,300 "	=	\$1,502,100
Moulding sand..	22,700 "	=	34,000
Red-brick clay.....	559,200 "	=	669,000
Totals.....	1,082,200 "	=	\$2,205,100

According to these returns the business of mining fire-clays and other crude materials of a refractory nature is steadily increasing in extent and in value.

BRICKS.

The statistics of brick also are from Hon. James Bishop, Chief of the Bureau of Statistics.

Hackensack River yards.....	31,500,000
Raritan and South River yards.....	84,000,000
Raritan Bay and Matavan Creek yards.....	18,000,000
Trenton and Kinkora yards (including 9,000,000 pressed bricks)....	32,900,000
Delaware River (Pea Shore).....	8,000,000
Scattering yards, Camden and South Jersey*.....	6,000,000
Yards elsewhere in State (estimated).....	6,000,000
Total.....	186,400,000

The product is valued at \$1,480,700.

These figures show a large increase over the total returns received at the Survey office, for the years 1881 and 1882.

Eight fire-brick establishments report a total production of 20,500,000 fire-brick.

LIME.

The manufacture of pure lime, for building and manufacturing purposes, from the white, crystalline limestones of Sussex county, is car-

* Estimate of Mr. Augustus Reeve, of Camden.

ried on near Hamburg, by two firms, viz., Sayre & Vanderhoof, who have their kilns at the side of the railroad south of the village, and by the Hamburg Lime Company; and at McAfee Valley, by the White Rock Lime and Cement Company. The total product of these companies, in 1883, amounted to 121,000 barrels, besides what is sold for agricultural uses. The demand for these limes is increasing, necessitating the erection of two additional kilns at McAfee Valley and giving full employment to the kilns at Hamburg. All of the kilns are of improved pattern and have fire-chambers separate from the kiln-shaft, and all use wood. The greater part of the product is shipped to Jersey City and New York, where it competes with the best lime from Glens Falls and the Hudson river valley.

XII.

PUBLICATIONS OF THE SURVEY.

THE ANNUAL REPORTS OF THE STATE GEOLOGIST are printed as part of the legislative documents of the State. They are largely distributed by the members of the Legislature. Extra copies are distributed by the members of the Board of Managers, and the State Geologist also distributes copies to libraries, institutions of learning, and, as far as possible, to persons interested in such work. A list is kept of those to whom distribution is made regularly. Most of the extra copies of the reports of preceding years are all distributed.

THE REPORT OF THE FIRE AND POTTERS' CLAYS OF NEW JERSEY, with a map of the clay district of Middlesex county, published in 1878, has been very widely distributed. There are copies still on hand for distribution.

A PRELIMINARY CATALOGUE OF THE FLORA OF NEW JERSEY, prepared by N. L. Britton, Ph.D., was printed in 1881, and distributed to botanists for their remarks, corrections and additions. A great many of the plants have been noticed in only a single place in the State. By the circulation of this catalogue among botanists, it is hoped that many new localities of rare plants will be discovered, and the list thoroughly revised. The catalogues are to be returned after two or more seasons, and the notes in them used in making out a more perfect catalogue, for general circulation throughout the State. Only 600 copies were printed, and these have already been placed in the hands of working botanists, and much has already been accomplished in its revision. The work commends itself to all lovers of botanical science, and we are promised their hearty co-operation in completing the revised edition.

A TOPOGRAPHICAL MAP OF A PART OF NORTHERN NEW JERSEY, on a scale of one mile to an inch, is printed, and has been dis-

tributed to some extent. In addition to the delineation of boundaries, streams, roads and geographical matter, it has on it contour lines of level, so that the elevations of the surface above mean-tide are accurately marked on all parts of it. This map has been very generally approved, and is in demand for laying out drains, ditches, water-works, roads and railroads, and for selection of building-sites, and as a study for drives, bicycle excursions, etc.

SHEETS NOS. 3 AND 4 OF THE TOPOGRAPHICAL MAP OF NEW JERSEY, as referred to on pages 11 and 12 of this report, will be printed and ready for distribution about April 1st, 1884.

GEOLOGICAL MAP OF NEW JERSEY. Scale, six miles to an inch. The improvements going forward in the State call for a revision of our map very often. The one which was printed with the annual report of 1882, and was corrected up to that date, had some corrections in railroads, some minor improvements in the geological coloring, and much was added in new places along the sea-shore, and the life-saving stations were all located.

The results of the Survey are intended for the benefit of the citizens of the State, and the Board of Managers have charge of and direct the distributions of its collections, reports and maps. The addresses of the members of the Board are given on page 3 of this report, and application made for publications to them, or through them to the State Geologist, will be received and given due attention.

XIII. EXPENSES.

The expenses of the Survey are kept strictly within the annual appropriation of \$8,000, and all bills and liabilities incurred up to date are paid in full.

XIV.

PERSONS EMPLOYED.

My own time has been occupied with the business of the Survey, providing the men and means for carrying forward the work steadily and efficiently. I have been much interested in helping to carry forward various works for turning geological science to its practical and useful applications.

Prof. JOHN C. SMOCK, Assistant Geologist, has been engaged specially in a review of our iron mines and mining industries, as is shown in this report. He is also engaged in collecting the materials necessary for the completion of the geology to accompany the new topographical maps now being prepared.

In consequence of the pressing need for Topographical Surveys and maps upon which to properly locate and describe the geology, and the limited funds at our disposal, it has been thought proper to spend all that could be saved of the appropriation on the Topography. And neither Professor Smock nor myself have drawn pay for full service, but have found partial occupation in other scientific work.

C. CLARKSON VERMEULE, C.E., assistant in charge of the Topographical Survey, has been pressing his work forward steadily through the entire year.

PETER D. STAATS, A.M., assistant to Mr. Vermeule, has been engaged, principally, in surveying and mapping roads during the entire year.

FRED. W. BENNETT, B.S., assistant to Mr. Vermeule, has been engaged in leveling and sketching for Topography during nine months.

PHILIP H. BEVIER, B.S., assistant to Mr. Vermeule, has been engaged in leveling and sketching for Topography during six months of the year.

GEO. HILL, C.E., assistant to Mr. Vermeule, has been engaged in leveling and sketching for Topography during six months of the year.

CYRUS W. F. SPROUL, student Rutgers Scientific School, has been engaged in leveling and sketching for Topography during nine months of the year.

JOHN G. TAIT, student Rutgers Scientific School, rodman, fifteen weeks.

WM. L. HAYNES, student Rutgers Scientific School, rodman, ten weeks.

CHARLES DESHLER, student Rutgers Scientific School, rodman, seven weeks.

ARTHUR C. PAYNE, student Rutgers Scientific School, rodman, seven weeks.

FRANK VAN BRACKLE, student Rutgers Scientific School, rodman, seven weeks.

WM. F. MARVINE, rodman, ten weeks.

In the chemical department no chemist has been steadily employed, but needed chemical investigations have been made by F. A. Wilber, M.S., Assistant Professor of Chemistry in Rutgers Scientific School.

Prof. J. S. Newberry, of Columbia College, New York City, has nearly completed his monograph of the fossil fishes of our Triassic sandstone, and it will soon be ready for publication, with full descriptions and drawings.

Prof. R. P. Whitfield, of the American Museum of Natural History, is making progress with his work of figuring and describing the invertebrate fossils of the Cretaceous formations of New Jersey. One hundred and eighty species are described; four hundred and ninety-six figures are drawn and ready for the engraver.

Dr. N. L. Britton is still engaged in revising, correcting and improving the Catalogue of Plants of New Jersey, and it is expected that he will soon have entered upon the list very nearly all the plants growing in the State.

XV.

WORK TO BE DONE.

PLAN FOR THE COMING YEAR.

The work of the Survey is now mainly directed to perfecting and arranging materials for publication. The essential and important part of this is to have accurate and reliable maps upon which to delineate the various results which have been attained. For this purpose the Topographical Surveys will be prosecuted with all the dispatch the means at our disposal will allow.

The Topographical Maps, Sheets Nos. 3 and 4 of the series, shown on map facing page 11, are now done. Sheet No. 7 is all engraved; Sheet No. 2 is drawn and ready for the engraver; Sheet No. 16 is nearly all drawn, and will soon be put in the hands of the engraver. The surveys for Sheets Nos. 6 and 17 are well advanced, and will be completed the coming summer. The surveys for Sheets Nos. 9 and 13 will next be taken up, and, if possible, be completed the coming summer.

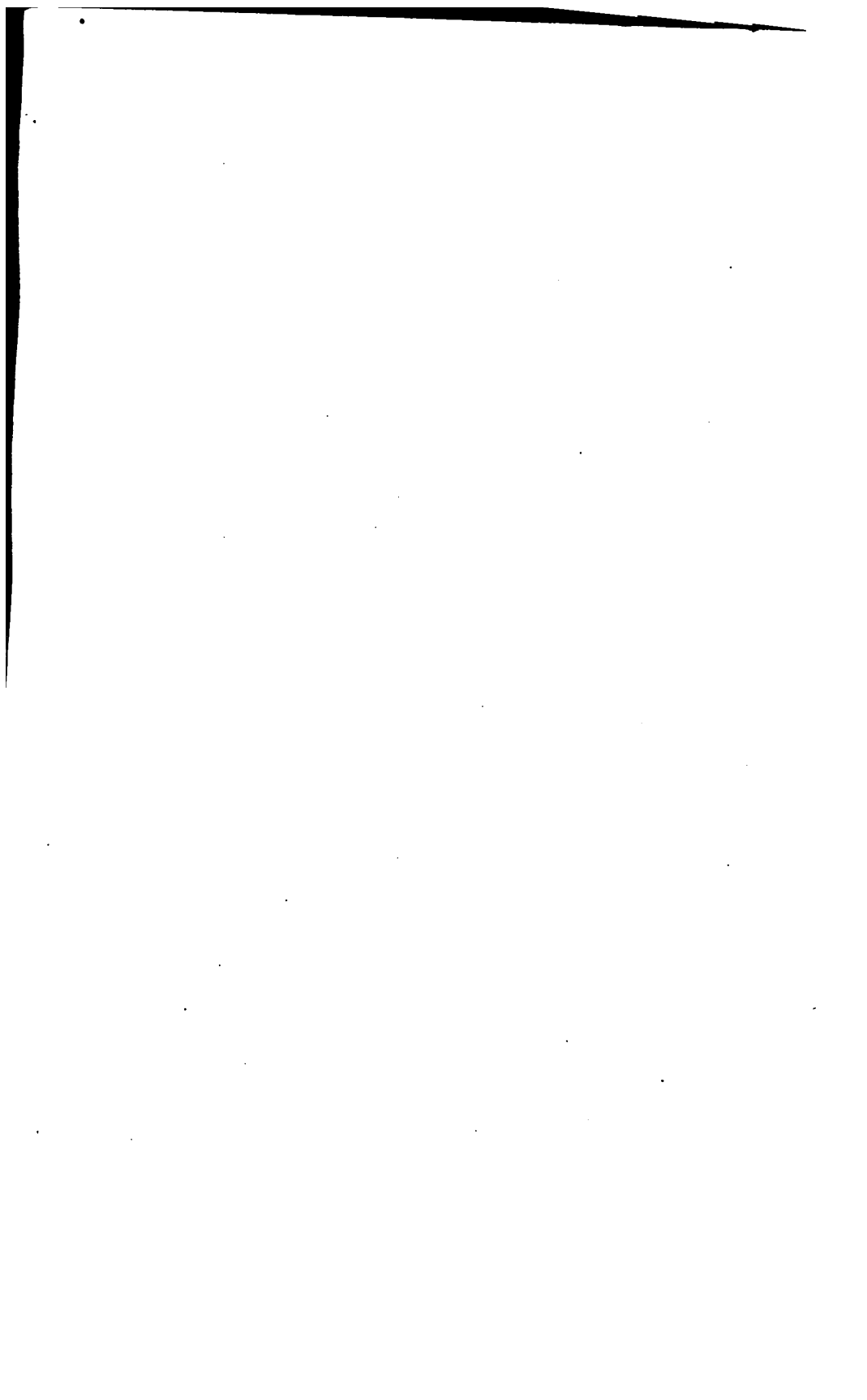
Questions connected with the economic uses of geological and natural products are continually arising, and we give to them as much attention as possible at the time they are brought up. And geological notes are being collected and made ready for use whenever a final report shall be prepared.

The larger part of the Invertebrate Fossils of the Cretaceous Formation are described and drawn, and the lithographer is at work drawing them on stone, and a considerable portion of them will be printed in the course of the year.

The catalogue of the plants of the State is going forward, and we are glad to report that several hundred amateurs are helping to fill out and perfect it.

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